Library

FEB 6 1942

Vol. 69 FEBRUARY, 1942 No. 2

Bulletin

of the

Torrey Botanical Club

145

Editor

Harold W. Rickett

Associate Editors

Irving W. Bailey — Henry Allan Gleason
Edward W. Berry — Arthur H. Graves
Stanley A. Cain — John W. Shive
M. A. Chrysler — R. P. Wodehouse

Michael Levine

CONTENTS

Heterocaryotic Vigor in Neurospora ..... *B. O. Dodge* 75
Stem Rot of Tuberous Begonia ..... *John T. Middleton* 92
The Dependence of Certain Annual Plants on Shrubs in Southern California Deserts ..... *F. W. West* 100
Secondary Vascular Tissues of the Oaks Indigenous to the United States—III. A Comparative Anatomical Study of the Wood of Leucobalanus and Erythrobalanus ..... *Simon Williams* 115
Culture of Isolated Roots of Acacia melanoxylon ..... *James Benner* 130
Cytogeography of Oxydendrum arboreum ..... *J. T. Baldwin, Jr.* 134
The Genus Delphinium in North America: Series Echinatae of Subsection Subscaposa, and Miscellaneous Noteworthy Species. *Joseph Ewan* 137
New North American Umbelliferae. *Mildred E. Mathias and Lincoln Constance* 151
Supplementary Notes on American Menispermaceae—II. *B. A. Krukoff and H. N. Moldenke* 155
Index to American Botanical Literature 169

Published for the Club monthly except
July, August and September
by
THE SCIENCE PRESS PRINTING COMPANY
N. QUEEN ST. AND McGOVERN AVE.
LANCASTER, PENNSYLVANIA

THE TORREY BOTANICAL CLUB

Officers for 1942

President: C. STUART GAGER

Vice-presidents: JOHN A. SMALL, CLYDE CHANDLER

Recording Secretary: JOHN W. THOMSON

Corresponding Secretary: HAROLD C. BOLD

Treasurer: W. G. WHALEY

Editor: HAROLD W. RICKETT

Business Manager: MICHAEL LEVINE

Bibliographer: MRS. LAZELLA SCHWARTEN

For information about the publications and proceedings of the Club, and about membership, dues, and meetings, see Torreya, published bimonthly by the Club.

The Bulletin of the Torrey Botanical Club

Subscriptions, dues, and inquiries about back numbers should be sent to the office of publication, N. Queen St. and McGovern Ave., Lancaster, Pa., or to Dr. W. G. Whaley, Department of Botany, Barnard College, New York, N. Y. Correspondence about advertisements and circulation should be addressed to Dr. Michael Levine, Montefiore Hospital, New York, N. Y. Communications about exchanges should be sent to Dr. Harold C. Bold, Department of Botany, Barnard College, New York, N. Y. Manuscripts intended for the Bulletin should be sent to Dr. H. W. Rickett, The New York Botanical Garden, Bronx Park (Fordham Branch P. O.), New York, N. Y.

Claims for missing numbers must be made within 60 days from the date of issue.

The subscription price of the Bulletin of the Torrey Botanical Club is $6.00 a year except to active members of the Club. Of the annual membership dues, $3.00 covers a year's subscription to the Bulletin.

Torreya. Bimonthly; established 1901. Of the annual dues $0.50 is for a year's subscription to Torreya; price to non-members, $1.00. Manuscripts intended for publication in Torreya should be addressed to Dr. W. J. Bonisteel, Department of Biology, Fordham University, New York, N. Y.

Entered as second-class matter October 8, 1940 at the post office at Lancaster, Pa., under the Act of March 3, 1879. Accepted for mailing at the special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph 4, section 538, P. L. & R.

BULLETIN OF THE TORREY BOTANICAL CLUB
69(2): 75–91 FEBRUARY, 1942

HETEROCARYOTIC VIGOR IN NEUROSPORA[1]

B. O. DODGE

Races of *Neurospora* normally develop certain structures which are characteristic of species of this genus. There are the orange-colored monilioid conidia, the incipient ascocarps, the microconidia, and finally, when two races of opposite sex are grown together, the ascocarps with asci. Races *C4* and *C8* of *N. tetrasperma*, for example, which will be mentioned many times in this report, produce all the structures just mentioned. They are of opposite sex in their reactions. Race *C4* produces a fluffy aerial growth in Difco potato dextrose agar tube cultures. The conidia tend to be of a rosy pink color. On the same medium race *C8* produces fewer conidia and much less aerial growth. The conidia of *C8* are bright yellowish-orange in color.

HOMOCARYOTIC AND HETEROCARYOTIC MYCELIA

When two races of *N. tetrasperma* which are of opposite sex are grown together there is a rapid migration of nuclei through the openings at the points of anastomoses (Dodge 1935a, 1935b). Some years earlier the writer (1930, 1931) realized that a nuclear migration through the openings in the cross-walls of the radiating hyphae must occur to account for the peculiar distribution of ascocarps (1930a, fig. 3). Actual proof of such a migration was not forthcoming until later (1935a). If races *C4* and *C8* are grown in a plate culture the nuclei of race *C8* migrate over to the *C4* side by way of the small openings in the cross-walls (fig. 1). Even though the cells of races *C4* and *C8* may contain from one to several nuclei each, these nuclei are all haploid and in each race all exactly alike genetically. Each race is therefore *homocaryotic*. After nuclei of the *C8* race have migrated to mingle with the *C4* nuclei in a common cytoplasm, however, the cells of the mycelium contain two different kinds of nuclei, and this part of the mycelium is now *heterocaryotic*. The growth from such a mycelium and from many of the conidia (fig. 2) produced on the new growth will also be heterocaryotic.

A NEW DWARF NON-CONIDIAL RACE OF NEUROSPORA

As the result of X-ray treatment or of natural somatic mutations we now have races of *Neurospora* which produce few, if any, monilioid conidia. Otherwise such "non-conidial" races may be perfectly normal.

Recently we have obtained a new non-conidial race, one that does not seem to produce any incipient ascocarps. Furthermore, it is a dwarf race

[1] Paper presented at the meeting of the National Academy of Science, held in Madison, Wisconsin, October 13–15, 1941.

[THE BULLETIN for January (69: 1–74) was issued January 2, 1942]

which grows so slowly that when transplanted to a fresh medium growth is first evident only after two or three days. Later the growth rate increases somewhat. It usually requires a week or more for the mycelium to cover an area 2.5 cm. in diameter. A culture in a Kolle flask will grow across from one side of the flask to the other, a distance of 9.5 cm., in about four weeks at room temperatures. This race will be referred to as *"Dwarf 16."*

In tube cultures a week or ten days old, the growth at the lower part of the slant takes on a bright lemon- or cadmium-yellow color, and the growth becomes more or less warty or nodular. At the top of the slant in

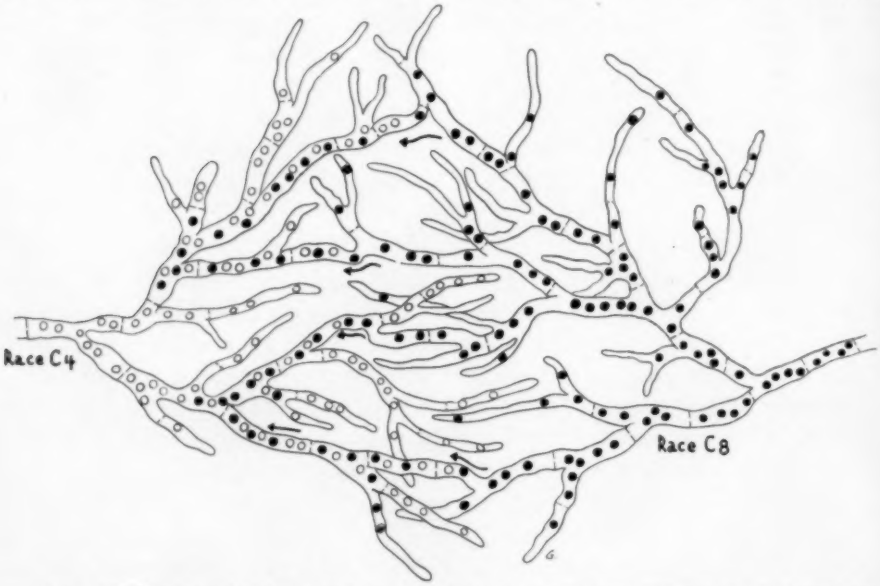

FIG. 1. Diagram showing how the nuclei in the mycelium of race *C8* (*Neurospora tetrasperma*) may migrate through the openings at the points of anastomoses to commingle with nuclei of race *C4* in a common cytoplasm. This part of the mycelium of race *C4* is thus changed from a homocaryotic to a heterocaryotic condition. The mycelium of *C8* has remained homocaryotic.

tubes or at the outer margin in plates, the aerial growth is somewhat fluffy and pale buff or only slightly yellowish.

Race *C8* usually grows a little faster than does race *C4*. When *C4* and *C8* are grown together in a plate the rate is about like that of *C8* alone. *C8* will grow 9 cm. in three or four days, depending on the temperature. It is apparent that both *C4* and *C8* grow many times as fast as does *Dwarf 16*.

SEX REACTION TYPE OF DWARF 16

In earlier work with races of *N. tetrasperma* carrying the so-called dominant lethal *I* (Dodge 1934) dwarf races were frequently obtained from

l-ascospore progeny. It was rarely possible to determine the sex or sex-reaction type of any of these dwarf races, which usually died after some weeks. However, if one allows the dwarf to grow alone for several days in culture before introducing the tester races a sex reaction may occasionally occur. The sex of *Dwarf 16* was determined by first allowing transplants to grow about four days in tube cultures of Difco potato dextrose medium. Races *C4* and *C8* were then used as testers, *C4* being introduced into one

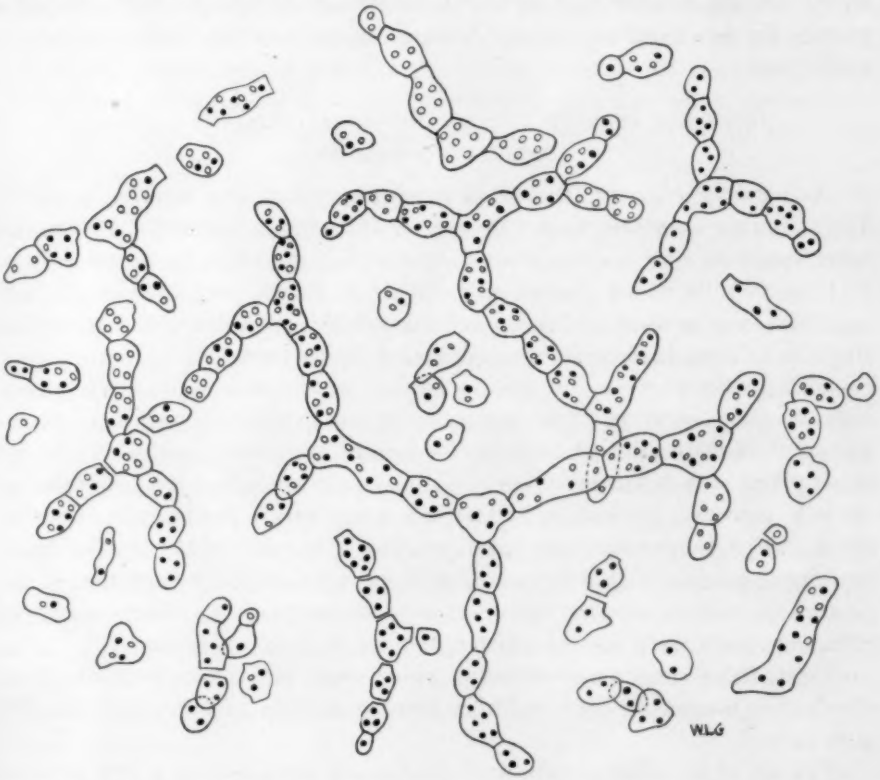

FIG. 2. Diagrams of monilioid conidia and hyphal fragments, the nuclear condition being purely arbitrary; some conidia are represented as homocaryotic, others as heterocaryotic. White and black used to distinguish differences in sex, or in some other factor pairs.

culture of *Dwarf 16*, and *C8* into another culture of *Dwarf 16*. The tube which now contained both *Dwarf 16* and race *C8* soon showed fluffy aerial growth and masses of yellowish-orange conidia were soon formed. Such large quantities of conidia are not formed in *C8* cultures under the same conditions. While numerous incipient ascocarps are always produced in cultures of *C8*, some of them being rather large, in the combination culture *Dwarf 16* + *C8* these incipient fruit bodies were more numerous, and they grew rapidly at first. They remained sterile, however, never producing asci.

Cultures of *Dwarf 16* to which transplants from a culture of *C4* had been added, also showed a rapid development of aerial growth and the production of excessive amounts of conidia which were more yellowish-orange than are conidia of *C4* when it is grown by itself. The incipient ascocarps developed rapidly, soon becoming fertile, discharging quantities of ascospores. *Dwarf 16* must, therefore, be opposite in sex to that of *C4* which we say is sex *A*, and it is of the same sex as *C8*, or sex *a*. *Dwarf 16* was also tested against another pair of wild-type testers, *S1* and *S9*, with the same results. By our usual methods of testing for sex reaction, *Dwarf 16* is unisexual, sex *a*.

DIFFERENT TYPES OF HETEROCARYOTIC MYCELIA AND CONIDIA INVOLVING DWARF 16

As noted previously, *Dwarf 16* produces few if any conidia by itself. The following questions arise: Do any of the conidia abstricted in the culture *Dwarf 16* + *C4* contain *Dwarf 16* nuclei in addition to nuclei of race *C4*? Are conidia which contain only *Dwarf 16* nuclei ever abstricted? Both questions may be answered in the affirmative. Proof was obtained at various times as follows, the results are considered here as a whole.

Thin sowings of conidia from a culture of the now supposedly heterocaryotic race *Dwarf 16* + *C4* were made on the surface of hard agar plates. The conidia were allowed to grow for twelve or more hours at 27° C. By this time growth from the larger conidia was rather extensive. The smallest conidia, however, showed only emerging germ tubes. Both kinds were isolated, but particular care was taken to select a number of the smaller later-germinating ones. Within two or three days, it was usually clear that of the 1-conidium isolates not just two or, at most, three types of cultures had been obtained; there were instead quite a number of different types.

First, there were many cultures which grew vigorously from the first, developing masses of deep cadmium-orange conidia and finally ascocarps with spores.

The aerial mycelial growth and the conidia produced in a few cultures were of a bright lemon-yellow color. Growth was vigorous, the color was certainly not that of *C4* by itself, and formation of ascocarps was so long delayed that we had hopes of discovering a startling cytoplasmic inheritance from the yellow dwarf. While such an effect is neither excluded nor proved as yet, in time these yellow cultures all produce ascocarps. Fertility was of a low grade, however.

Certain cultures of a third type were like typical *C4*, although the conidial masses were rather darker pink, bordering on orange in color. They never produced fertile ascocarps, and they reacted under tests as sex *A*, the same as race *C4*.

A fourth type of isolate was distinguished by its slow rate of growth and failure to produce very many conidia, at least not until after a week or ten days. They were described as dwarfish, but they were in no sense dwarfs like *Dwarf 16*, and no yellow color ever appeared. The surface mat of mycelium remained a very light pink. Transfers from such cultures sometimes produced more conidia, resembling more *C4* in this regard. Although cultures of this type all reacted as sex *A*, they are being studied further, as will be noted at another time. They may prove highly interesting.

A fifth type would include all dwarf isolates which finally became bright lemon-yellow and showed nodular growth at the base of the slant. They reacted as sex *a*, the same as *Dwarf 16*, which in fact they were, barring any cytoplasmic effects due to their association with *C4* nuclei in the same cytoplasm.

Finally there were in a sixth type isolates which during two or three weeks made very little growth beyond a few short hyphal branches. Some of these eventually grew enough to show that they were real *Dwarf 16* type, but a number died without making much growth.

In all, nearly 400 1-conidium isolates were obtained at various times from cultures in which *Dwarf 16* and race *C4* were growing together. Of this number at least 50 isolates proved to be real yellow dwarfs like *Dwarf 16*. Two hundred and eighteen (218) isolates sooner or later produced ascocarps with ascospores. The remaining isolates were recorded as producing conidia but no ascocarps with spores. All of this type that were tested proved to be of sex *A* reaction type like that of *C4*. A number of these conidial cultures showed a very decided yellowish cast or coloration of mycelia and conidia as though some cytoplasmic effect had been carried over because of a former association in the same cytoplasm with *Dwarf 16* nuclei. As long as such isolates were observed no fertile ascocarps were discovered, but further study would very likely prove that they were actually bisexual and thus contained also nuclei from the *Dwarf 16;* this would account for the yellow coloration.

THE QUESTION OF CYTOPLASMIC INHERITANCE RAISED

It is clear from the results given above that one can obtain conidia from a mixed culture, *Dwarf 16* + *C4*, which develop not only typical *C4* types, testing as sex *A*, but also conidia which developed yellow dwarf growth very like that of *Dwarf 16* which by itself abstricts few if any conidia. As further proof that the mycelium in the mixed cultures is actually heterocaryotic we find that ordinarily a large percentage of the isolated conidia give rise to a third type, vigorously growing fertile cultures producing ascocarps which mature ascospores. This would give us only three types of isolates, whereas, as noted previously, one can readily distinguish a number of dif-

ferent types of cultures. The reasons for this apparent anomaly may well be worth considering. The first point to be emphasized here is that nuclei from *Dwarf 16* race and those from race *C4* can, at will, be brought together in a common cytoplasm giving us a heterocaryotic mycelium. Furthermore, the two nuclear components or elements in such growth can be isolated and grown separately again.

If it is the *Dwarf 16* nuclei that originally migrated over into the cells of race *C4* mycelium, then one may well ask which race contributed the cytoplasm carried in the conidia which are abstricted and which carry only *Dwarf 16* nuclei. It is not at present clear from the evidence just how much such a cytoplasm-nucleus relation may account for the intermediate types of cultures which one may obtain when he starts with only two kinds of nuclei. The second type described above might be considered as showing a cytoplasmic effect.

There appear not only various grades of fertility (some cultures maturing ascocarps quickly, others only after many days) but gradations in coloration, amounts of conidia produced, and striking differences in vigor or growth rates among the isolates. Some of these differences must be due to the relative numbers of the two kinds of nuclei included in particular conidia isolated. The writer (1930b) has proved that microconidia of species of *Neurospora* will germinate, but very slowly, only after about two days. Hyphae from the germ tubes grow very slowly for several days. The mycelium is not that of a dwarf, however. Eventually the mycelia from microconidia become rather normal, so that matings can be made with them as with mycelia from the monilioid conidia or ascospores. The reasons for the very slow growth-rate at first are clearly the small size of microspores and the fact that they would contain only a single nucleus each. Tertiary conidia are very small and germinate slowly. In isolating single conidia from a mixed culture *Dwarf 16* + *C4*, one can with sufficient care pick out conidia which will give rise to *Dwarf 16* types. The germ tubes from such conidia develop a sort of distorted rosette type of branching. If the conidium is very small, germinating slowly but developing long branched germ tubes, a sex *A* reacting type of growth may be obtained. Some of these cultures are typical of race *C4*, while others certainly fail to develop as normal *C4* types. The cultures will, however, be unisexual, sex *A* in their mating reactions.

Large rapidly germinating conidia will usually give fertile cultures with ascospores. It has been shown (Dodge 1927) that the size of ascospores of species of *Neurospora* depends largely on the number of nuclei included in the spore at its origin. The great difference in the sizes of conidia and hyphal fragments is also due to a certain extent to the number of nuclei included at abstriction. Conidia formed on the heterocaryotic mycelium *Dwarf 16* + *C4* must vary not only in the kinds of nuclei they contain, but also in the

relative numbers of each kind. If a conidium should contain only a single nucleus of *Dwarf 16*, it would very probably be unable to develop much beyond the formation of a germ tube. A small ascospore containing only a single nucleus of a similar dwarf race might well be able to grow into a good dwarf because of the much larger amount of cytoplasm in the ascospore. Whether the difference in the number and kinds of nuclei in conidia accounts wholly for the differences in types of growth, may be questioned, however. This material certainly should be studied from the standpoint of the effects of the cytoplasm, as well as the possibility that *Dwarf 16* contains of itself two kinds of nuclei.

NUCLEAR MIGRATIONS BETWEEN RACES OF THE SAME SEX

Up to now the writer has been inclined to the view that the nuclear migrations proved to occur in cultures of *N. tetrasperma* are due to sex attractions, or to sex hormones, or to the attractions of "opposites" (which may or may not be the same things). While "protoplasm" may be seen streaming from cell to cell and through openings where hyphae anastomose, there is no proof that nuclei are carried along in the stream. It would seem strange if nuclei of two races of the same sex, but differing in other genetic factors could migrate to mingle in a common cytoplasm. From the experiments now to be described it can be said that other forces than sex attractions do cause nuclei to migrate freely from hyphae of one race into the cells of another race which is of the same sex reaction type.

Aerial growth in mixed cultures, *Dwarf 16* + race *C8*, soon shows much more vigor than does the mycelium in cultures of *C8* alone. Many more conidia are also formed at the crown of growth. These conidia are usually a bright yellow-orange in color. Furthermore, the incipient ascocarps are very numerous and they increase rapidly in size, at first resembling young ascocarps which develop in cultures in which races of opposite sex are being grown. Usually incipient ascocarps of race *C8* grow very slowly at first, only a few of them ever attain the size of fertile fruit bodies. In cultures of *Dwarf 16* + race *C8*, as noted previously, the little bodies enlarge very rapidly from the first, but after attaining fair size, cease further development. So far as we have been able to discover, none of them ever produces asci.

In a mixed culture, *Dwarf 16* + *C8*, with a commingling of nuclei from both races in a common cytoplasm, the cells would be homocaryotic for sex, but heterocaryotic for certain other pairs of factors represented in the two kinds of nuclei. *Dwarf 16* has the genotype *aDc*, while race *C8* has the genotype *adC*.[2] Two methods were employed to prove that such heterocaryotic mycelia and conidia were present in the mixed cultures, *Dwarf 16* + *C8*. These experiments will be described below.

[2] *A, a* are sex reaction factors; *C, c* are factors governing production of conidia; *D, d* factors for deliquescent ascus abortion (Dodge 1935; Dodge & Seaver 1938).

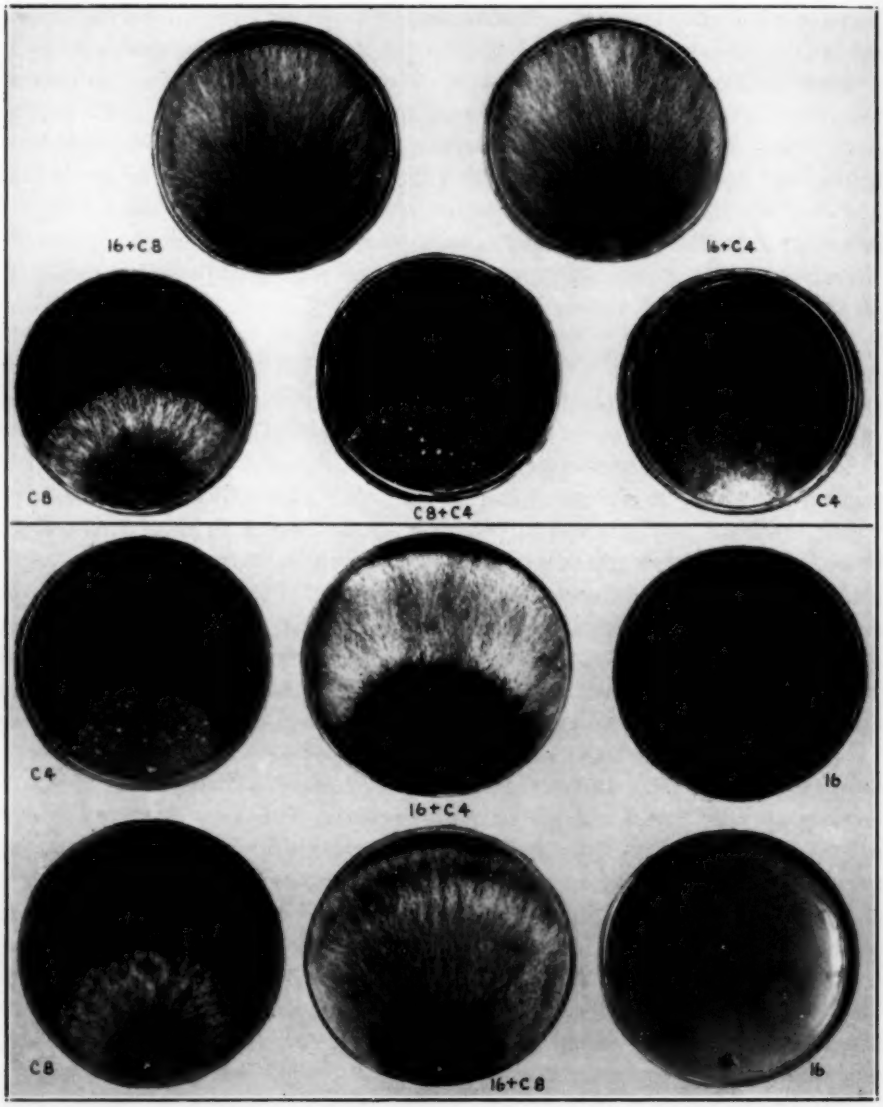

FIG. 3. Above: Photographs of cultures 24 hours old in plates 9 cm. in diameter and incubated at 30° C. The mycelium of the two heterocaryotic races, *Dwarf 16 + C8* and *Dwarf 16 + C4*, have completely covered the plates while that of race *C4* is not yet half way across. The heterocaryotic race *C8 + C4* has grown about the same distance as has race *C8*. Below: Comparative amounts of growth in plate cultures at room temperatures for 34 hours. *Dwarf 16* has made no visible growth in either culture. The mycelia of races *C4* and *C8* have not grown half way across as yet, while the heterocaryotic mycelia have just about covered the plates.

INCREASED VIGOR INVOLVING RACES OF OPPOSITE SEX

As noted above, when the *Dwarf 16* was grown in culture with race *C4* which is of the opposite sex, mixed cultures showed not only a more vigorous growth but also larger quantities of conidia than are ever developed in culture of *C4* or *C8* alone. The differences in the growth rates of these three races are much more readily demonstrated in plate cultures. If one transplants some mycelium of race *Dwarf 16* into one plate, some conidia of race *C4* into a second plate, and some conidia or mycelium from the mixed culture *Dwarf 16* + *C4* into a third plate, and allows growth to proceed for from 24 to 40 hours, depending on the temperature, it will be seen that little or no growth is evident in the first plate, *Dwarf 16*, at the end of this time. (It requires about two days for growth to be apparent.) Mycelium of race *C4* would have grown nearly half way across the plate while the heterocaryotic mycelium, *Dwarf 16* + *C4*, would have grown completely across the plate (fig. 3). Similar tests repeated many times show that the heterocaryotic mycelium grows from two to three times as fast as does that of race *C4* alone. Growth by the dwarf for the first day or two, as noted above, is negligible.

A very striking demonstration of these different growth rates may be obtained by using U-tubes. In this case the potato dextrose agar medium should be prepared by using tap water instead of distilled water and the medium should be sterilized intermittently in a steam sterilizer at about 92° C. This is to avoid driving the air from the agar in the U-tubes.[3] If distilled water is used and the medium is autoclaved, there is very little oxygen left in the agar, so that even though, as Denny (1933) has shown, only a minute quantity of oxygen is necessary for growth, the mycelium will make little headway down into the agar. With the agar prepared as noted above, one may inoculate the agar in one arm of a U-tube with mycelium of *Dwarf 16*, the agar in one arm of a second tube with *C4* and a third tube with the heterocaryotic conidia of *Dwarf 16* + *C4*. At the end of a week's time it may be seen that the surface of the slant in the tube containing *Dwarf 16* is nearly covered with the mycelium of the dwarf which has just begun to turn yellowish at the center. Race *C4* will usually have grown down through the agar and appeared in the other arm of the tube and begun to produce some of the pale pink conidia in both arms. In the third tube containing *Dwarf 16* + *C4* the mycelium would have grown around through the agar very quickly and begun to produce large quantities of brightly colored yellowish-orange conidia. If one watches the growth of

[3] Since this paper was presented Beadle & Tatum (Proc. Nat. Acad. **27**: 409–506. 1941) have described a much better method for observing and measuring growth rates. They use horizontal tubes 13 cm. inside diameter and about 40 cm. in length. The ends are bent at a 45° angle. The medium is poured in to fill the tube half full. Our U-tubes were much larger in diameter.

the mycelium in the three tubes it will be very evident that the heterocaryotic mycelium has grown very much more rapidly than that of race *C4* and produces a great many more conidia than are formed by the *C4* race alone.

The great increase in vigor illustrated in figure 3 occurred when the medium was inoculated with conidia or with fragments of mycelia which contained two kinds of nuclei, *Dwarf 16* and *C4;* that is, when the transplanted mycelia or conidia were already heterocaryotic. This increased vigor may also be demonstrated when one inoculates a plate first with mycelium from *Dwarf 16* and then at a point nearby with conidia of race *C4*. Other plates may be inoculated, one with *Dwarf 16,* and the other with race *C4* alone for comparison. Up to a certain time there is very little difference between the amount of growth in the *C4* plate and that in the plate containing the mixture *Dwarf 16* and *C4*. Then it will be seen that the mycelium of the mixed culture is growing faster than is the mycelium of race *C4,* and by the end of the first or the second day, depending on the temperature, increased vigor is very evident. That the mycelium in the mixed culture has now become heterocaryotic may be proved by plating out the conidia formed at the outer margin. The smaller, more slowly growing conidia isolated will develop either the yellow *Dwarf 16* or pinkish growth much like that of *C4*. The mycelia from the larger, more rapidly growing conidia eventually produce fertile ascospores. Intermediate types of growth will be obtained because of quantitative differences in the nuclei included in the conidia isolated. This point will be discussed below.

INCREASED VIGOR INVOLVING RACES OF THE SAME SEX REACTION

It was stated above that in the mixed cultures in which *Dwarf 16* (sex *a*) and race *C8* (sex *a*) were grown, the aerial growth was more vigorous and it produced more conidia than was evident in the culture containing race *C8* alone. By inoculating three plates as before, one with *Dwarf 16,* the second with race *C8,* and the third with mycelium or conidia from the mixed culture of *Dwarf 16* + *C8,* it was shown that the mycelium of the mixed culture grew very much more rapidly than did the mycelium in the culture *C8*. As a rule, race *C8* grows somewhat faster than does race *C4*. The heterocaryotic mycelium[4] *Dwarf 16* + *C8* on the other hand grows about as rapidly as does heterocaryotic mycelium *Dwarf 16* + *C4*. When race *C4* is grown with race *C8* in a mixed culture so that a heterocaryotic mycelium *C4* + *C8* is developed, it has been shown that the latter mixed culture, the heterocaryotic race *C4* + *C8* does not grow appreciably faster than does *C8* alone. In some tests race *C8* alone grows the faster. In fact, not infrequently in tube cultures a mixed culture, race *C4* + *C8,* produces fewer

[4] See below for proof that this mycelium is actually heterocaryotic.

conidia than does race *C4* alone. It is well known that race *C8* seldom produces on our potato dextrose agar very many conidia. By using U-tubes as described above for demonstrating increased growth of the heterocaryotic mycelium *Dwarf 16* + *C4* the great increase in vigor and in the production of conidia by *Dwarf 16* + *C8* can be emphasized.

Race *C8*, when grown on Difco potato dextrose agar media is characterized by the paucity of conidia and the tendency to form amorphous blotches or patches (Pease 1936) on the surface of the culture. These patches later turn a sordid reddish brown color which gives the culture the appearance of being badly contaminated with yeast and bacterial colonies. This effect is well brought out in U-tube cultures. The patches are not prominent at first in plates, being covered by the fluffy mycelium, which later collapses. When, however, nuclei of *Dwarf 16* come into the same cytoplasm with nuclei of this race *C8* a most beautiful transformation takes place. No sordid amorphous blotches now mar the surface of growth. Instead, a vigorous mycelial growth develops on the surface and soon a crown of bright yellowish-orange or cadmium-yellow conidia appears.

More accurate determination of growth rates was later obtained when small blocks of agar bearing fresh mycelial growth were used as transplants. When conidia alone are used there are bound to be errors because recently formed conidia germinate more quickly than do old or dried conidia. If it is necessary to transplant conidia, one should allow growth to proceed for a number of hours and then begin taking measurements from the limits of growth at the end of this preliminary period. At 30° C. it was found for example, in one set of plates, that starting with transplants of blocks of agar, race *C4* grew approximately 3 cm. during the first 24 hours, while race *C8* grew 4.1 cm. and race *C4* + race *C8*, heterocaryotic grew only 3.8 cm. During the same period heterocaryotic races *Dwarf 16* + *C4* grew 8.2 cm.

PROOF FOR MIGRATION OF NUCLEI OF THE SAME SEX

To avoid confusion, a detailed description of the two sets of experiments by which it was proved that two genotypically different kinds of nuclei of the same sex may commingle in a common cytoplasm was postponed in order to emphasize the main feature of this paper, namely, increased vigor of certain heterocaryotic mycelia over that shown when the two components in each case are grown separately. The first experiments involved race *Dwarf 16* and race *C8*. Sowings of conidia were made as described above. Germinating conidia were isolated, great care being taken to isolate the smallest, more slowly growing conidia. The mere fact that one could in this way obtain 1-conidium cultures of what appeared to be pure race *C8*, would mean nothing, since *C8* produces its own conidia. But if a considerable number of the small isolates grew to become yellow dwarfs like *Dwarf 16* this would indi-

cate perhaps that just as in the mixed culture of *Dwarf 16* + race *C4*, conidia are cut off bearing only *Dwarf 16* nuclei, in spite of the fact that the dwarf produces few if any conidia by itself. Of the 1-conidium isolates obtained from the mixed cultures, *Dwarf 16* + *C8*, 15 grew to become good yellow dwarfs that could not by tests be distinguished from *Dwarf 16*. Eighteen grew to look and react like pure *C8*. There were several somewhat different types of cultures which grew vigorously from the start; many of them were bright lemon-yellow or cadmium-orange in color. None of these ever produced fertile ascocarps, neither did transfers from them. The isolate cultures that were entirely unlike either pure *Dwarf 16* or race *C8* indicated that in such cases nuclei from *Dwarf 16*, as well as nuclei from race *C8*, had become associated in these conidia because of nuclear migrations, just as if two races of opposite sex were grown together.

Other sowings of conidia from cultures of *Dwarf 16* + *C8* were made, care now being taken to select the larger, more quickly growing conidia. Most of the isolates grew vigorously and produced masses of highly colored conidia. None of these cultures produced fertile ascocarps. Some 30 of them were then grown separately with both *C8* and *C4* testers. No ascocarps with asci were produced in cultures with *C8*, but in all cultures with *C4* fertile ascocarps were matured. The critical point in these tests was to find two entirely different kinds of ascocarps in some of the fertile cultures. If the isolated condia contained both *Dwarf 16* and *C8* nuclei which are of the same sex reaction type, sex *a*, then nuclei from the inserted tester *C4* could join with either of the two kinds of nuclei, *Dwarf 16* or *C8*, to bring about fertilization. Both *C4* and *C8* races carry a certain recessive lethal "*d*" (Dodge 1935) for deliquescent ascus abortion. Asci homozygous, *dd*, for this lethal would abort. Such asci would arise if nuclei from *C8* (sex *a*) joined with nuclei from *C4* (sex *A*). But if nuclei of *Dwarf 16*, sex *a*, joined with nuclei from *C4*, then asci with spores would be found in fertile ascocarps because the nuclei from *Dwarf 16*, carry the wild type *D* allele of *d*. Asci being heterozygous *Dd* would produce spores.

It was easy to distinguish these two kinds of ascocarps in many of the mixed cultures because on Difco potato dextrose agar medium at the temperatures then prevailing many of the aborting asci become indurated, dark brown in color, and devoid of ascospores. This feature is very helpful because of certain additional sterility factors operating in these complex hybrid asci, often lead to ascus abortion even though the asci are heterozygous *Dd*, and ordinarily become indurated. Furthermore, some of the very numerous ascocarps in these cultures would mature at least a few spores. There was a sufficient number of cultures in which all asci in some ascocarps produced a full quota of spores, while all asci in other ascocarps in the same culture produced only indurated asci with no spores, to prove that a heterocaryotic

mycelium may often arise through nuclear migrations involving nuclei of the same sex.

Another experiment was carried out to prove this point. As a result of crossing a certain vigorous non-conidial race with race *C4* a bright yellow vigorously growing race, *Race 6*, was obtained. This race reacted with race *C4* to produce fertile ascocarps, but when grown with race *C8* the mixed cultures remained sterile. Conidia from these mixed cultures (*C8* + *6*) were isolated. None gave fertile cultures. Again 1-conidium isolates were made as before, but from an isolate culture this time. The new isolates were grown with *C4* and with *C8* separately. None of the cultures with *C8* (sex *a*) produced fertile ascocarps. In many cultures with *C4* two kinds of ascocarps were easily distinguished. One kind produced many asci, all of which aborted and usually became indurated without producing any ascospores. This would indicate that they arose from the cross *C4* + *C8*. Other ascocarps produced some asci with spores, showing that these arose from the cross *C4* + *6*. Since race No. 6 is *acD*, and *C4* is *ACd*, the asci would be heterozygous for all three pairs, including *Dd*, and some spores would be delimited. The asci from this cross would show a great lack of fertility, however.

HETEROCARYOTIC VIGOR AND HYBRID VIGOR DISTINGUISHED

When it is recalled that *Dwarf 16* produces few if any conidia, it is all the more clear that increased growth and the production of such large quantities of conidia in mixed cultures, *Dwarf 16* + *C8*, must be due to the combined effects of bringing together in the same cytoplasm the two kinds of nuclei, *Dwarf 16* and *C8*. The same conclusion may be drawn from the effects visible when *Dwarf 16* and *C4* are grown together. This appears to be a condition or a situation which has not been reported previously. One may grow two different races of a fungus, races either of opposite or of the same sex reaction, separately in cultures under controlled conditions where the growth rates may be studied carefully and the production of conidia noted. Then, at will, one can bring the nuclei of the two races together in a common cytoplasm, with the result that the heterocaryotic mycelium grows with such astonishing vigor and produces conidia in such great quantities. Since this vigor is expressed in connection with heterocaryotic structures this type of vigor is being described as *heterocaryotic vigor* to distinguish it from the true hybrid vigor manifested by diploid organisms such as our industrial yeasts or by higher plants or animals. What is the meaning of this heterocaryotic vigor? Is it at all comparable, for example, to hybrid vigor in corn? Can anything be learned about hybrid vigor in general by a careful study of heterocaryotic vigor in *Neurospora*?

Robbins (1941) in a recent paper on hybrid vigor (heterosis) in tomatoes

has suggested that hybrid vigor may be due to the ability of the heterotic hybrid to synthesize a full quota of vitamin-like growth substances, whereas the parents of the hybrid were not able to do this. He has suggested to the writer personally that perhaps a somewhat similar explanation might account for heterocaryotic vigor, modifying the explanation to cover the haploid organization of the structures involved.

On this basis one could say that *Dwarf 16* is able to synthesize adequate amounts of, say, vitamins or growth substances 1, 2, 3, and 4, but be unable to synthesize enough of 5, 6, 7, and 8. On the other hand, race *C4* (or race *C8*) may not be able to synthesize enough of vitamins 1, 2, 3, and 4, but be able to produce an adequate supply of 5, 6, 7, and 8. When nuclei of the two races are brought together in a common cytoplasm, the amounts of growth substances now synthesized by one of the components of the heterocaryotic mycelium supplement the amounts of growth substances synthesized by the other component. The mycelium now fortified strongly by an optimum of vitamin-like growth substances manifests a great increase in vigor, and excessive amounts of conidia are produced.

In crossing *Dwarf 16* and race *C4* a number of new dwarf races have been obtained, races which are self-sterile, but which cross readily with both testers *C4* and *C8*. Whatever the results of further studies of *Dwarf 16* and the new dwarfs should be, the main point at issue here will not be affected, namely, that heterocaryotic mycelia containing nuclei from both *Dwarf 16* and either race *C4* or race *C8* show greatly increased vigor of growth and increased production of conidia over either *C4* or *C8*.

This factor complex concerned with increased heterocaryotic vigor is heritable. Certain new dwarf races, such as race *Dwarf 130*, one of the unisexual progeny of the cross *Dwarf 16* × *C4*, has much the same morphological and physiological characters as *Dwarf 16*. When nuclei from *Dwarf 130* mingle with nuclei of either *C4* or *C8* heterocaryotic vigor is manifested.

The new dwarf races which remain sterile when grown alone, but which fruit with both testers *C4* and *C8* are of great interest. Just how so many of the ascospores from which they were derived could have contained two nuclei of opposite sex at their origin, and at the same time both nuclei carry factors for dwarfness, is not easily explained even on the basis of errors due to random selection. If *Dwarf 137*, for example, while remaining self-sterile, is able to produce ascospores with spores when grown with *C4* but only ascocarps with deliquescent aborting asci with *C8*, it may be possible to separate the two components, providing that these components can be grown by themselves. Instead of being a dwarf this race *137* should really show heterocaryotic vigor, unless neither of its components is able to synthesize adequate amounts of certain growth substances.

INDIVIDUAL HOMOCARYOTIC INHERITED VIGOR

In previous discussions we have distinguished between heterocaryotic vigor expressed by structures whose cells contain two or more different kinds of haploid nuclei, and true hybrid vigor expressed by diploid structures whose nuclei are actually diploid. A third type of vigor is shown by certain *Neurospora* races obtained by crossing *Dwarf 16* with race *C4*. When one mates these two races the only real hybrid structures obtained are the asci with their fusion nuclei. Reduction is followed by a third division which provides each ascus with eight haploid nuclei. In the obligately heterothallic species, such as *N. crassa*, eight ascospores are then formed. The ascus of *N. tetrasperma* normally contains four spores which have two nuclei each at their origin. These nuclei are usually of opposite sex reaction. Occasionally an ascus has five ascospores. In this case two of the spores are small and contain only one nucleus each at their origin. By selecting these small ascospores one obtains unisexual races. Several hundred new races, haploid progeny of *Dwarf 16* + race *C4*, were obtained by selecting ascospores at random. No attempt was made to isolate only the small unisexual ascospores; the slowness of germination and the irregularity of the germ tubes insured the selection of a large percentage of new dwarf races. While this work has not been carried on sufficiently to warrant drawing any conclusions, it may be said that a number of dwarf races have been obtained. These all remain sterile when grown alone but only a very few of them react as unisexual races when tested against races *C4* and *C8*. In many cases the new dwarfs fruit with both *C4* and *C8*, which proves conclusively that they are actually bisexual, although self-incompatible.

Recently Dickson (1939) reported that he crossed two races of *N. crassa* and obtained a segregant which he thought showed hybrid vigor because it grew more vigorously than did either of the races crossed. On further consideration he questioned this idea, because the new race did not show at certain temperatures much if any increase in vigor over the parent races at those same temperatures. Dickson should have realized that even if his new race had shown a greater growth rate than the parents at all temperatures he could not have called it hybrid vigor because his new race was not a hybrid originally. A race of *N. crassa* arises from a single ascospore which is provided at its origin with a single haploid nucleus. Even though the cells of the mycelium may contain from one to several nuclei each, these nuclei are all haploid and they are all exactly alike genotypically. Since the mycelium of Dickson's race was not diploid it could not very well have shown true hybrid vigor under any conditions of growth whatsoever.

The heterocaryotic vigor which is described here is in quite a different category because the cells of the mycelium in each instance contain at least

two genotypically different kinds of haploid nuclei, regardless of whether the two kinds are of the same or of opposite sex in their reactions. A number of the new races grew very vigorously from the start and produced large quantities of conidia without ever developing ascocarps with asci. Numbers of these races were tested for their sex reactions and were found to react with only one of the two tester races, which shows that they were unisexual. Since neither of the parents, *Dwarf 16* and race *C4*, is a vigorous race, it is clear that the vigor now shown by these new races must be due to a recombination of factors governing growth and production of conidia. On the hypothesis that vigor of growth depends upon the ability of the race to synthesize adequate amounts of growth substances, individual vigor must be distinguished from heterocaryotic vigor, because, in the case of individual vigor, the genes or factors concerned with the synthesis of growth substances must be included in a single haploid nucleus of the ascospore giving rise to the new race. Even though true hybrid vigor, heterocaryotic vigor and the individual vigor, just mentioned, may be due to exactly the same or similar causes, they should be distinguished because they are often manifested in quite different ways; they are expressed in connection with particular structures and at particular times in the life cycle of the organisms concerned.

Dickson (1939, p. 127) refers to his earlier work (1935) on growth rates of various segregant races of *Coprinus sphaerosporus*, claiming that certain haploid segregants showed hybrid vigor. He was not referring to dicaryons as manifesting "hybrid" vigor. He distinctly says this of his haploid segregants. Dicaryotic vigor might very well be expressed when the nuclei of two haploid segregants are brought together in the same cytoplasm. Dickson did not, however, study growth of dicaryons as compared with that of the individual components. Such a study would no doubt have borne fruit. After rereading the papers referred to above and a third paper by Dickson (1936) one must be convinced of the necessity for distinguishing heterocaryotic vigor, and individual haploid segregant vigor from each other and both from true hybrid vigor. If we do this we shall avoid confusion, we shall be better understood and, what is more important, our students will think more clearly when we are discussing growth, reproduction and inheritance in the fungi.

SUMMARY

A new yellow non-conidial dwarf race, *Dwarf 16*, which by itself grows very slowly, about 2 cm. per week, reacts as a unisexual race, sex *a*, when grown with the tester races *C4* and *C8* of *Neurospora tetrasperma*. When this dwarf is grown with race *C4*, which is of the opposite sex, sex *A*, nuclear migrations occur so that nuclei of both races come together in a common heterocaryotic mycelium, which shows a great increase in vigor of growth and production of conidia. The new mycelium grows two or three times as fast as

does that of race *C4*. The same phenomenal increase in the growth rate and production of monilioid conidia occurs when *Dwarf 16* is grown with race *C8*, which is of the same sex reaction, sex *a*. This increased vigor is referred to as *heterocaryotic* vigor and it is distinguished from individual haploid segregant vigor and from true hybrid vigor which is expressed in connection with diploid organisms. It is suggested that perhaps the hypothesis offered by Robbins to account for hybrid vigor in tomatoes, for example, may be applied here. That is, the growth substances synthesized by *Dwarf 16* supplement those synthesized by race *C4* (or *C8*) so that the heterocaryotic mycelium has an optimum of those vitamin-like substances that control growth.

Preliminary work in crossing *Dwarf 16* with race *C4* shows that this factor complex is heritable. Some of the haploid segregants carry in turn very similar factors for heterocaryotic vigor.

THE NEW YORK BOTANICAL GARDEN
NEW YORK

Literature Cited

Denny, F. E. 1933. Oxygen requirements of *Neurospora sitophila* for formation of perithecia and growth of mycelium. Contr. Boyce Thompson Inst. **5**: 95–102.

Dickson, H. 1935. Studies in *Coprinus sphaerosporus*. II. The inheritance of various morphological and physiological characters. Ann. Bot. **49**: 181–204.

———. 1936. Studies in *Coprinus sphaerosporus*. III. Inheritance of factors affecting the growth-rates at different temperatures of certain strains. Ann. Bot. **50**: 219–246.

———. 1939. The inheritance of growth-rate in *Neurospora crassa* with special reference to hybrid vigor and cytoplasmic inheritance. Ann. Bot. N. S. **3**: 113–129.

Dodge, B. O. 1927. Nuclear phenomena associated with heterothallism and homothallism in the ascomycete *Neurospora*. Jour. Agr. Res. **35**: 289–305.

———. 1930a. Material for demonstrating sexuality in the ascomycetes. Torreya **30**: 35–39.

———. 1930b. Breeding albinistic strains of the *Monilia* bread mold. Mycologia **22**: 9–38.

———. 1931. Inheritance of the albinistic non-conidial characters in interpecific hybrids in *Neurospora*. Mycologia **23**: 1–50.

———. 1934. A lethal for ascus abortion in *Neurospora*. Mycologia **26**: 360–376.

———. 1935a. A recessive factor lethal for ascospore formation in *Neurospora*. Bull. Torrey Club **62**: 117–128.

———. 1935b. The mechanics of sexual reproduction in *Neurospora*. Mycologia **27**: 418–438.

Dodge, B. O. & Seaver, B. 1938. The combined effects of the dominant and the recessive lethals for ascus abortion in *Neurospora*. Am. Jour. Bot. **25**: 156–166.

Pease, Dorothy. 1936. Bacterium-like amorphous patches associated with certain races of *Neurospora*. Am. Jour. Bot. **23**: 612–618.

Robbins, W. J. 1941. Growth of excised roots and heterosis in tomato. Am. Jour. Bot. **28**: 216–225.

BULLETIN OF THE TORREY BOTANICAL CLUB
69(2): 92–99 FEBRUARY, 1942

STEM ROT OF TUBEROUS BEGONIA

JOHN T. MIDDLETON[1]

INTRODUCTION

Within recent years the tuberous begonia, *Begonia tuberhybrida* Voss, has become a popular and valuable floricultural crop in California. The plant is well adapted to both garden and glasshouse culture, particularly in coastal, temperate areas. In the summer of 1938 the writer's attention was called to a disease causing the collapse and death of tuberous begonia plants in several large commercial glasshouses in the San Francisco Bay region. Later the same trouble was found in commercial plantings at Capitola, California. Upon examination of diseased material it was found that the malady was due to a fungous infection. The causal fungi were identified as *Pythium intermedium* de Bary and *P. ultimum* Trow and their pathogenicity demonstrated in inoculation tests. It is the purpose of this paper to discuss the symptoms of the disease, the causal organisms, host range, and certain control measures.

REVIEW OF LITERATURE

Species of *Pythium* have previously been reported as pathogens of *Begonia* spp. In 1925 Braun (1925) reported that *Pythium debaryanum* Hesse, *P. debaryanum* var. *pelargonii* Braun, and *P. splendens* Braun were capable of infecting an unidentified species of *Begonia* by inoculation. The writer considers *P. debaryanum* var. *pelargonii* synonymous with *P. debaryanum*. Pape (1927) in Germany stated that leaf cuttings of the Gloire de Lorraine begonia (*B. socotrana* Hook × *B. dregei* Otto & Dietr.) were destroyed in the propagation bench and that *P. debaryanum* was probably implicated; he later (1933) confirmed this report and added that this and other *Pythium* spp. were the causes of a seedling disease. Flachs (1931) also mentions *P. debaryanum* as the cause of a seedling disease of *Begonia* spp. Sharples (1930) reported a natural infection of an unidentified species of begonia in Malaya by *P. splendens;* no description of the disease was given. Swift (1932) in New York described some control measures for a leaf and stem rot of *B. semperflorens* Link & Otto caused by *P. debaryanum*. According to Dr. B. O. Dodge,[2] Swift's fungus was later identified by Charles Drechsler as *P. ultimum*. In 1938 (Middleton *et al.*, 1938) a disease

[1] Grateful appreciation is expressed to Professor M. W. Gardner, Division of Plant Pathology, University of California, for advice and assistance and the use of controlled temperature facilities.

[2] In correspondence with the writer, Nov. 22, 1938.

affecting the roots, crown, basal portion of the stem and leaves of *B. semperflorens* was reported as occurring both in California and Missouri; the causal agents were designated as *P. debaryanum*, *P. splendens*, and *P. ultimum*. Subsequently the writer (Middleton 1938) presented a preliminary report of natural infection of tuberous begonia by *P. intermedium* and *P. ultimum*, and also described a stem rot of *B. lloydii* (horticultural name) caused by

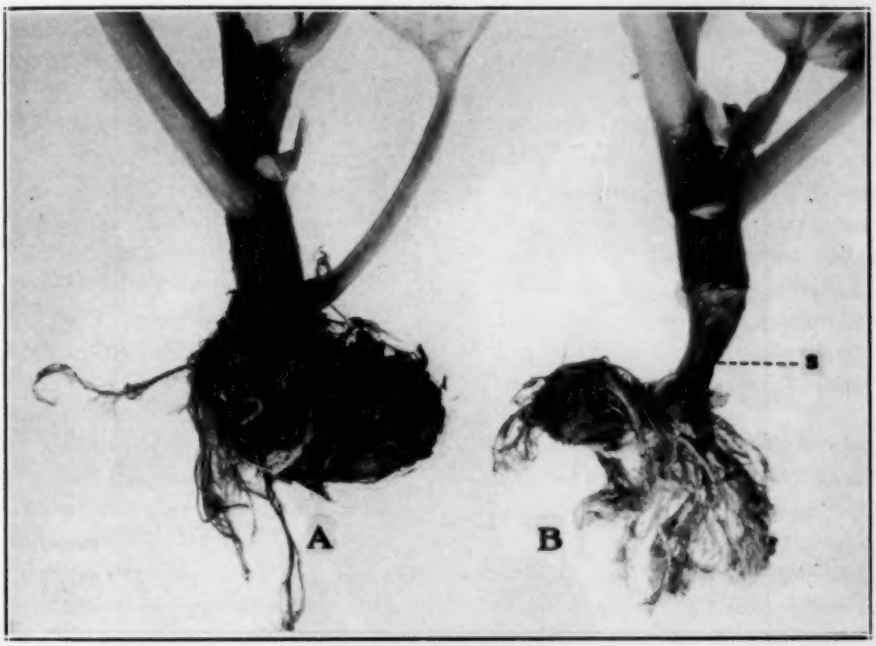

FIG. 1. Stem rot of tuberous begonia: A, non-inoculated control; B, *s* symptoms produced on young tuberous begonia plant by *Pythium intermedium* 16 days after inoculation in the greenhouse. The lesion is sunken and vertically disposed, consuming a large portion of the stem. Identical symptoms are produced by *P. ultimum*.

P. ultimum. This was followed by a report (Nance 1939) that a *Pythium* sp. was responsible for a stem rot of tuberous begonia in New York and New Jersey. A culture of the latter fungus was obtained from Dr. A. W. Dimock and identified as *P. ultimum*.

SYMPTOMS OF THE DISEASE

The stems of naturally infected plants exhibit light brown, watersoaked lesions which are not usually sunken but occasionally may be. These lesions are vertically disposed and vary somewhat in size, though generally from 5 to 28 mm. in length and 3 to 8 mm. in width (figs. 1 A, B, 2). Lesions often coalesce, encompassing the stem, in advanced stages of the disease. Occasionally petiole and lamina infections have been observed. Petiole symptoms

resemble those of diseased stems; infected laminas have irregularly defined watersoaked areas which turn brown and become flaccid, the entire blade eventually collapsing.

Natural root and tuber infections have seldom been observed. When roots and tubers are infected they are discolored, watersoaked, and later pass into a flaccid state.

FIG. 2. Stem rot of tuberous begonia: *X*, Natural stem infection due to infection by *Pythium intermedium*. This type of darkened, not usually sunken lesion is most common and is usually associated with a leaf axil; this symptom is usually produced about 7 days following infection. Identical symptoms are produced by *P. ultimum*.

Petal infection has also been noted to occur under conditions of excessive overhead irrigation; petal symptoms are comparable with the laminar symptoms presented above but may be confused with those caused by *Botrytis cinerea* Pers. These symptoms are easily differentiated only if *Botrytis* is sporulating.

THE CAUSAL ORGANISMS

The fungi, *Pythium intermedium* and *P. ultimum*, were readily obtained

in pure culture from diseased material by tissue plantings made on plain water agar. The use of this medium permitted isolations to be made from badly diseased material without complication by contaminants.

Morphology. Both organisms produce a copious amount of white cottony aerial mycelium when grown on cornmeal, oatmeal or potato-dextrose agars. *Pythium intermedium* displays a pulvinate habit of growth, whereas that of *P. ultimum* is arachnoid. The hyphae of both organisms are cylindrical, smooth, nonseptate when young, measuring 1.7–6.5 μ in diameter (mean 3.5 μ) becoming septate with age.

Sporangia are produced freely on the substrates used, being most numerous on potato-dextrose agar; extramatrical sporangia predominate over intramatrical ones. The sporangia of *Pythium ultimum* are borne singly and are spherical when acrogenous, measuring 15.3–27.6 μ in diameter (mean 20.3 μ). Occasional intercalary bodies are found which are limoniform and vary in size from 16.1 μ in width and 19.5 μ in length to 23.7 μ and 27.4 μ, respectively (mean 19.1 μ × 22.8 μ). The sporangia of *P. intermedium* are typically catenulate, though occasionally borne singly and then terminal. Catenulate sporangia are usually spherical, measuring 17.3–24.7 μ in diameter (mean 21.5 μ), often up to 13 in a series, sessile or separated by short stalks. Sessile sporangia are sometimes pyriform.

Transfers of mycelial fragments from four-day old pea-broth cultures produce an abundance of sporangia when placed in sterile distilled water. The production of a vesicle at the tip of a short evacuation tube and the subsequent liberation of zoospores was commonly observed in *P. intermedium*. Sporangia of *P. intermedium* were also seen to germinate by the production of one to three germ tubes. All attempts to induce zoospore formation in *P. ultimum* were unsuccessful, the sporangia germinating by the production of from one to five germ tubes.

Oogonia of *Pythium ultimum* are produced freely when the fungus is grown on plain water agar. Oogonia are largely intramatrical, acrogenous, spherical, with a smooth, thin wall, measuring 17.1–25.3 μ in diameter (mean 20.6 μ). Antheridia are invariably of monoclinous origin and single, arising immediately below the oogonium and adjacent to it, somewhat clavate, short, upcurved, the apex contacting the oogonial wall. Infrequently two antheridia may be applied to the oogonium, in which case one of them is usually of diclinous origin from a proximal neighboring hypha. A prominent penetration tube is generally discernible.

Mature oospores of *Pythium ultimum* are aplerotic (not filling oogonial cavity), spherical, with a smooth, thick wall. The contents are somewhat granular, containing a single reserve globule and often a subspherical refringent body. Oospores measure 13.0–21.4 μ in diameter (mean 16.7 μ), including the oospore wall which is approximately 2.3 μ thick.

No oospores have been observed in any of the isolates of *Pythium intermedium;* this is in accord with the description of the species given by de Bary (1881) in which it is stated that oospores are unknown.

Temperature Relations. The relation of temperature to growth of the mycelium was determined for four isolates of *Pythium intermedium* and four of *P. ultimum*, from both stems and leaves of tuberous begonia. The culture tubes (2.1 × 20 cm.) used and the procedure followed in this study are those previously described by Tompkins and Gardner, (1935). Each tube used is provided with a glass dam at the open end. Thirteen milliliters of Difco cornmeal agar (pH 6.0) are added to each tube and allowed to cool to a uniform depth with the vessel in a horizontal position; the dam prevents the escape of the melted agar.

The tubes were inoculated near the dam at the open end with a small square of potato-dextrose agar containing the mycelium of the fungus cut from 3-day-old Petri dish cultures. Inoculated tubes were left at room temperature for 24 hours, the extent of growth at the close of the period being indicated by a wax pencil mark on the tube; subsequent measurements were made from this point.

Three tubes of each isolate were placed in a horizontal position in controlled temperature chambers at intervals of 3°, from 1° to 43° C. The cultures were incubated for a 72-hour period. The average growth in millimeters over 24-hour periods at the various temperatures is presented in table 1.

TABLE 1

Mycelial growth of Pythium intermedium and P. ultimum on Difco cornmeal agar at various temperatures

Degrees C.:	Average growth in millimeters over 24-hour period														
	1	4	7	10	13	16	19	22	25	28	31	34	37	40	43
Isolate															
P. intermedium															
Stem	2	4	7	11	14	16	21	23	22	21	5	t*	0	0	0
Stem	1	4	7	9	13	16	20	23	23	21	2	0	0	0	0
Leaf	1	4	7	9	12	16	19	23	24	19	8	1	0	0	0
Leaf	2	4	7	10	13	16	20	24	23	20	2	0	0	0	0
P. ultimum															
Stem	0	1	4	8	14	18	26	28	34	32	19	16	2	t	0
Stem	0	1	6	10	14	17	23	26	32	32	16	12	1	0	0
Leaf	t	3	6	13	15	18	23	27	31	34	30	23	t	0	0
Leaf	0	1	3	9	14	17	23	29	33	34	32	17	1	0	0

* t = trace.

The minimum temperature for growth of *Pythium intermedium* is approximately 1°, the optimum from 22° to 25°, and the maximum 34° C.; the minimum temperature for growth of *P. ultimum* is approximately 4°, the optimum from 25° to 28°, and the maximum 37° C.

While there are no recorded temperature relations of *P. intermedium* in the literature, the values given for *P. ultimum* are similar to those recently summarized (Tompkins *et al.* 1939).

Pathogenicity. Young tuberous begonia plants were grown in autoclaved soil in 6-inch pots. Pure cultures of *Pythium intermedium* grown on sterilized cracked wheat were added to the soil in one set and *P. ultimum* to that in a second set; to a third group was added sterilized cracked wheat. After from 14 to 20 days, 85 per cent of the plants in infested soil exhibited basal stem lesions. A few yellowed and wilted in the absence of any visible stem lesions; most of these were growing in pots infested with *P. ultimum,* although a few were observed to occur in pots in which *P. intermedium* was present. On removal these plants showed extensive root infection. Plants growing in soil containing only cracked wheat remained healthy.

Isolations made from artificially infected stems and roots proved pathogenic upon reinoculation, producing symptoms indistinguishable from natural infection.

In order to induce infection on the upper portion of the stem, probably naturally accomplished by zoospores and detached sporangia, small agar blocks containing the fungus mycelium were placed in the unwounded axils of the leaves and covered with sterile absorbent cotton saturated with sterile distilled water. After from 5 to 8 days infection was discernible. *Pythium ultimum* proved to be somewhat more pathogenic than *P. intermedium* when this technique was used. Isolations made from infected areas proved pathogenic upon reinoculation. No infection occurred when agar blocks devoid of fungus mycelium were similarly applied.

Leaf infection was obtained by placing agar squares containing the fungus on undetached and unwounded laminas. Plants so inoculated were placed in a moist chamber for 3 days and then removed to the plant bench. Two to 3 days later watersoaked areas developed which, upon isolation, yielded pure cultures of whichever fungus had been applied.

Further tests with both *Pythium intermedium* and *P. ultimum* demonstrated that stem and leaf isolates were equally pathogenic upon cross inoculation.

An experiment was devised to ascertain the ability of both *P. intermedium* and *P. ultimum* to cause damping-off of tuberous begonia seedlings. Two lots of five 6-inch pots each were filled with soil artificially infested with pure cultures of the fungi grown on cracked wheat; over this was placed one-quarter inch of sterile soil. Twenty-five seeds were then sown in each pot and the pots subirrigated. Two pots of soil mixed with sterile cracked wheat were similarly sown. Three weeks later the following survival counts were made: *P. intermedium* 53, *P. ultimum* 6, and checks (not inoculated) 202.

The pathogenicity of *P. intermedium* and *P. ultimum* to rooted cuttings

of *Begonia semperflorens* was determined. Using the soil and pot procedure described above, 50 pots each were inoculated. From two to three weeks later all the plants inoculated with *P. ultimum* showed root rot to the exclusion of any stem lesions as typified in inoculation experiments with *B. tuberhybrida*. All plants inoculated with *P. intermedium* were apparently healthy.

The pathogenicity of both *P. intermedium* and *P. ultimum* to stems and leaves of *Begonia lloydii* was conclusively demonstrated by employment of the agar block technique already given.

CONTROL

Since the causal organisms are soil fungi, the disease may be adequately controlled by soil sterilization. Proper precautions should likewise be taken to insure use of sterile pots and flats.

When potted plants are grown in close proximity to one another the disease assumes considerable importance. In such instances the disease is often distributed throughout the plot by means of leaf infections due to the overlapping and contact of these parts. Excessive irrigation is conducive to the disease, particularly when watered by an overhead sprinkling system. In order to overcome these difficulties a good cultural practice should be established and maintained. Such a program would necessarily include proper spacing of plants, moderation in watering, abolishment of overhead sprinkling practices and provision made for good aeration of glasshouse space. If the disease assumes epidemic proportions and it is deemed necessary to rely upon fungicidal control, copper-containing sprays such as ammoniacal copper, Bordeaux, Burgundy, or Cuprocide may be employed. Swift (1932) recommends soil applications of semesan.

SUMMARY

A stem rot of tuberous begonia, *Begonia tuberhybrida*, occurring in California, New York, and New Jersey is described.

The disease may attack plants of any size or age and is most severe under conditions of high soil and air moisture and from moderate to high temperature.

Symptoms of the disease consist of soft, unsunken or sunken, watersoaked lesions which are vertically disposed and may ultimately encompass the stem, causing the stem to collapse. Root, petiole, lamina, and petal infections are also reported.

The causal organisms are *Pythium intermedium* and *P. ultimum*.

The temperature-growth relations of the organisms were determined. The values for *P. intermedium* are: minimum 1, optimum 22–25°, maximum 34° C.; the values for *P. ultimum* are: minimum 4°, optimum 25–28°, maximum 37° C.

Infection of healthy tuberous begonias was obtained by artificial inoculation. *Begonia lloydii* was found susceptible to both causal organisms; *B. semperflorens* was susceptible only to *P. ultimum*.

The causal fungi were able to cause damping-off of tuberous begonia seedlings.

The disease may be satisfactorily controlled by using sterile soil, pots, and flats, good cultural procedures, and copper-containing fungicides.

Division of Plant Pathology, University of California
Riverside, California

Literature Cited

Braun, Harry. 1925. Comparative studies of *Pythium de Baryanum* and two related species from geranium. Jour. Agr. Res. **30**: 1043–1062.

Bary, A de. 1881. Zur Kenntniss der Peronosporeen. Bot. Zeit. **39**: 553–558.

Flachs, Karl. 1931. Krankheiten und parasiten der Zierpflanzen. 558 p.

Middleton, J. T. 1938. Plant diseases caused by *Pythium* spp. observed in California in 1938. U. S. Dept. Agr. Plant Disease Reporter **22**: 354–356.

Middleton, J. T., Tucker, C. M., & Tompkins, C. M. 1938. Pythium disease of fibrous-rooted begonia. Phytopathology (Abstr.) **28**: 672.

Nance, Nellie W. 1939. Diseases of plants in the United States in 1938. U. S. Dept. Agr. Plant Disease Reporter Suppl. 119, 289 p.

Pape, H. 1927. Eine Vermehrungs-Krankheit bei Begonien Blattstecklingen. Gartenwelt **31**: 35–36.

———. 1933. Krankheiten und Schadlinge der Begonien. *In* Fotsch, K. A., Die Begonien. Ihre beschreibung, kultur, züchtung und geschichte. Eugen Ulmer, Stuttgart, 254 p.

Sharples, A. 1930. Division of Mycology. Ann. Rept. for 1929. Dept. Agric. Straits Settlement and Fed. Malay States, Bull. 3 (Gen. Ser.): 62–72.

Swift, M. E. 1932. Pythium crown and stem-rot of begonia. Jour. N. Y. Bot. Gard. **33**: 141–143.

Tompkins, C. M., Ark, P. A., Tucker, C. M., & Middleton, J. T. 1939. Soft rot of pumpkin and watermelon fruits caused by *Pythium ultimum*. Jour. Agr. Res. **58**: 461–475.

Tompkins, C. M., & Gardner, M. W. 1935. Relation of temperature to infection of bean and cowpea seedlings by *Rhizoctonia bataticola*. Hilgardia **9**: 219–230.

BULLETIN OF THE TORREY BOTANICAL CLUB
69(2): 100–114 FEBRUARY, 1942

THE DEPENDENCE OF CERTAIN ANNUAL PLANTS ON SHRUBS IN SOUTHERN CALIFORNIA DESERTS

F. W. WENT

For the plant physiologist one of the most intriguing problems of plant ecology is the question why a given plant grows in a given place. Certain aspects of this problem are under investigation and are fairly well understood. The distribution of plants is partly determined by climate, partly by soil, and partly by biotic factors such as seed distribution. But within a given set of climatic and soil conditions a large number of species can occur. The plant sociologist has grouped these species into well defined units which are termed plant communities, associations, etc. It is assumed that within each of these communities micro-climatic and soil conditions and survival values are such that the members of this particular community are favored over others so that the community as such persists.

It is not intended in this paper to examine critically the various factors which contribute towards the distinctness of a community. The survival values, mutual elimination, and similar Darwinian concepts are probably overrated in their influence on communities (see Kooper 1927). Besides, these factors, being only names for complexes themselves, are in great need of critical study before they can be accepted as a basis for explanation. Everyone who considers the fact that almost identical collections of plants are grown in scores of botanic gardens in widely different soils and climates is constrained to admit that the potential range of environmental conditions for many individual plants is far larger than the actual range of the communities in which such plants normally grow. Many assumptions have been made to bridge this gap between experience and theory, but most are more ingenious than likely.

Most natural plant communities are highly complex and the factors which result in the establishment of these communities include: climate, chemical and physical composition of soil, water, supply and germination of seeds, succession stages, history of previous vegetation, climate and soil conditions at the time of establishment of the community, etc. This complexity makes an analysis of the causal relations between the plants in a community well-nigh impossible. In a few cases, however, a clearer insight has been obtained by analyzing communities which occur under relatively simple conditions. A few papers of importance for our problem will be discussed in some detail.

The first paper is one by Kooper (1927), who studied the pioneer weed communities which appear immediately after plowing of the (mostly weedless) rice and sugar cane fields in the plains of Pasuruan in East Java. When

left fallow for several months these fields develop a rich vegetation of annuals. Within a limited area (10 × 10 m.) never more than 30 species (17 as a mean) out of a possible 300 weeds occurring in the whole region were found by Kooper to be growing together. The abundance of a single species did not change gradually, but the changes were very abrupt and were parallel for a number of species. In this way a limited number of weed communities is formed, each characterized by a fairly large number of constantly associated species. The limits of these communities are relatively sharp, so that one community with its typical constants suddenly changes into another community with a number of different constants over a distance of a few meters. One of the most remarkable facts found in connection with these communities was that their composition was already determined at the time of the germination of the seeds. In special germination experiments Kooper sowed sets of viable seeds in recently plowed soil normally carrying communities which lack these species. The results were definite. Only when the species sown normally occurred in the community would they germinate; otherwise no germination took place at all, and no seedlings developed. Thus the distinctness of the community is due to "birth control," which very definitely proves that these weed communities do not arise through competition and survival of the fittest.

Although association between the various members of one community was found, there were no correlations between the physical and chemical properties of the soil and the plant communities which grew on them.

All the observations of Kooper point towards the conclusion that these weed communities arise through a mutual influence of the plants on each other, and more specifically through influence of the previous vegetation on the germination of seed. This mutual influence cannot be due to physical factors, such as shading, since the nature of the communities is already determined at the time of germination. It seems highly probable, therefore, that there is a chemical inter-relation between the plants in one community which determines their germination and occurrence.

Critics of Kooper have questioned the general occurrence in Java of the phenomena studied by him. From personal experience, however, I can confirm his observations. In fallow rice fields near Semarang in the middle part of Java, with climate somewhat different from that of Pasuruan, I observed the same communities in which all constants occurred in the same relative abundance. This also is a good argument against the supposition that the composition of these weed communities is determined by climatic conditions.

In an investigation of the epiphytes in a tropical rain forest another type of mutual influence between plants was found (Went 1940). When the occurrences of the various epiphytic ferns, orchids, Ericaceae, etc., were noted in connection with the host tree on which they were growing, it was discovered

that certain epiphytes are found almost exclusively on certain host trees. This relation is so constant that trees can be identified by the epiphyte communities which they harbor. This relationship is apparently not due to physical properties of the host tree or microclimatic differences in the habitat which the various host trees offer. Therefore, we reach a conclusion similar to that of Kooper: namely, that the occurrence of one plant, the host tree, determines the presence of a certain number of other plants, epiphytes, through some unknown agent, presumably chemical.

If such distinct causal relationships between the members of communities exist, it becomes necessary to determine whether similar relations exist in other plant communities and whether the growing together of many plants is generally conditioned by mutual influences of these plants. Such influences are very hard to demonstrate wherever a continuous layer of vegetation occurs, since in that case it is practically impossible to determine (except experimentally) which plants are mutually dependent. In the desert regions, however, such inter-relationships should be much easier to investigate since their vegetation cover is not continuous and only the plants which are growing in groups together and which are separated from others by stretches of bare soil could be considered to influence each other. Therefore, a preliminary sociological study was made in the Colorado and Mojave deserts in Southern California during the spring of 1941.

In a number of localities occurrence of certain plants, mostly annuals, in connection with shrubs was noted. Different types of ecological analysis were tried, and finally the following one was adopted, being the simplest and giving the clearest results. All shrubs were counted distant 3 m. or less from a line followed on foot through the vegetation. In this way the shrub vegetation was recorded of a transect with the approximate dimensions of 400×8 m. The shrubs were classified in two ways; in the first place, according to their species; and in the second place, according to whether or not a certain annual was found in close association with the shrub in question. Results of such ecological analyses are brought together in tables 1, 3, 4, and 5. From these tables it can be seen that some annuals are closely correlated with certain shrubs and seem to avoid others. The shrubs which favor one annual do not always harbor certain other annuals, and vice versa. A very clear case of such vicarious occurrence is provided by *Caulanthus lasiophyllus* (H. & A.) Payson and *C. cooperi* (Wats.) Payson (see table 3).

By analyzing vegetation in this way it is soon found that a certain number of annuals bear no relation at all to any shrubs or other pre-existing vegetation. They are found predominantly in open spaces between shrubs, and generally these are the plants which form the marvelous mats of color which adorn our deserts in spring. They seem to grow equally well, or sometimes even better, in places where they have no direct contact with other

TABLE 1

Occurrence of six plants (annuals except Hilaria) with different shrubs in Borego Valley
Figures in brackets refer to plants growing with dead shrubs

	Encelia farinosa Gray (living)	*Encelia farinosa* Gray (dead)	*Franseria dumosa* Gray	*Hymenoclea salsola* T. & G.	*Hyptis emoryi* Torr.	*Dalea schottii* Torr.	*Larrea tridentata* Cov.	*Opuntia echinocarpa* Engelm. & Bigel.	*Krameria canescens* Gray	*Mirabilis bigelovii* Gray	No connection with any shrub	Total number of plants observed
No. of shrubs in one transect	248	84	172	136	51	46	12	13	8	3	.....	772
Per cent shrubs harboring one or more specimens of the herbs												
Phacelia distans Benth.	30	(57)	50	68	47	20	7	46	62	100	.....	352
Malacothrix californica DC.	5	(35)	27	15	14	4	25	31	12	0	.....	125
Emmenanthe peduliflora Benth.	4	(36)	3	20	27	9	8	(31)	0	30	.....	99
Rafinesquia neomexicana Gray	1	(11)	12	4	0	2	0	8	12	70	.....	45
Hilaria rigida Thurb.) Benth.	2	(6)	8	4	(2)	0	0	0	0	0	.....	38
Eschscholtzia minutiflora Wats.	0	0	0	5	(4)	4	0	(31)	0	0	.....	22
Per cent distribution of each herb among the shrubs												
Phacelia	21	(14)	25	26	7	2	1	2	1	1	0	.....
Malacothrix	9	(23)	37	17	6	2	2	3	1	0	0	.....
Emmenanthe	10	(31)	6	27	14	4	1	(4)	0	1	2	.....
Rafinesquia	7	(20)	47	13	0	2	0	2	2	5	2	.....
Hilaria	13	(13)	34	13	(3)	0	0	0	0	0	24	.....
Eschscholtzia	0	0	0	32	(9)	9	0	(18)	0	0	32	.....

TABLE 2

Length of main stem and number of flowers of Rafinesquia neomexicana, growing in various shrubs in Borego Valley

	Number of specimens measured	Length in cm. (with extremes)	Number of flowers
In open, not with shrubs	4	16(10–25)	1.7
Unknown dead shrubs	5	19(15–25)	1.8
Dead *Encelia farinosa*	6	35(25–55)	5.0
Living *Encelia farinosa*	1	30	4.0
Dead *Opuntia echinocarpa*	2	25	3.0
Living *Opuntia echinocarpa*	1	60	17.0
Larrea tridentata	2	30(25–35)	3.5
Dalea schottii	4	45(25–65)	5.0
Franseria dumosa	10	55(35–70)	9.5

plants. In general, it can be said that the closer these plants grow together the smaller they remain. They are not more vigorous in the neighborhood of shrubs than they are in the open.

Many other plants are found both under or near shrubs and in the open. These plants may or may not show a preference for certain shrubs. In general in this group there is not a very large size difference between the free-growing plants and those growing near shrubs.

The third category, however, consists of annuals which are always found near shrubs. If such a plant has accidentally germinated away from any shrub, its development is extremely poor and its size is only a fraction of what it normally is. Examples of such plants are *Phacelia distans* Benth., *P. tanacetifolia* Benth., *Caulanthus cooperi, Rafinesquia neomexicana* Gray. In table 2 the sizes and number of flowers of the latter plant have been noted

TABLE 3

Occurrence of annuals in connection with shrubs growing in hills north of Kramer, Mojave Desert

	Total number of shrubs observed	Per cent shrubs harboring annuals		
		Caulanthus lasiophyllus (H. & A.) Payson	*Caulanthus cooperi* (Wats.) Payson	*Phacelia tanacetifolia* Benth.
Franseria dumosa Gray	60	15	60	75
Aster abatus Blake	40	10	10	5
Larrea tridentata Cov.	15	100	20	90
Lycium andersonii Gray	18	.....	15	100
Grayia spinosa (Hook.) Moq.	16	60	30	100
Ephedra nevadensis Wats. (?)	3	50	100	80
Composite (*Tetradymia* ?)	11	.....	60	.....
Unknown dead shrub	3	100	100	.....
Free, not connected with shrub	.....	Many	Few	Very few

TABLE 4

Occurrence of Rafinesquia neomexicana Gray in connection with different shrubs. Approximate number of shrubs observed, total number of Rafinesquia present in those shrubs and percentage occurrence with each shrub noted for three different localities in the Eastern Mojave desert.

Name of shrub	Locality								
	North of Ludlow*			East of Ludlow			South of Amboy		
	No. of shrubs	No. of *Rafinesquia*	Per cent occurrence	No. of shrubs	No. of *Rafinesquia*	Per cent occurrence	No. of shrubs	No. of *Rafinesquia*	Per cent occurrence
Krameria canescens Gray	7	5	70	12	4	30	10	4	40
Franseria dumosa Gray	4	2	50	170	7	4	200	17	9
Hymenoclea salsola T. & G.	250	35	14	.....	.....	.....	.....	.....	.....
Larrea tridentata Cov.	50	6	12	100	2	2	100	0	0
Opuntia Unidentified composites	500	20	4	.....	.....	.....	25	0	0
Lepidium fremontii Wats.	.....	.....	.....	.....	.....	.....	100	0	.....
Dead plants	.....	23	.....	.....	1	.....	.....	2	.....
Ephedra	.....	.....	.....	.....	.....	.....	150	7	7
Free, not with shrubs	.....	2	.....	.....	3	.....	.....	1	.....

* Observations by Mr. P. Gorham.

TABLE 5

The occurrence of Phacelia distans and of Delphinium parishii with various shrubs, near Palmdale (S. W. Mojave Desert)

The reliability of a first analysis was checked in an adjoining region, where only the occurrence of *Delphinium* was noted, which was percentually almost identical with the first analysis. Mean of first and second analysis used for calculation of percentual occurrence.

	Total No. of shrubs observed in first analysis	*Phacelia distans* Benth. present		*Delphinium parishii* Gray present in		
		No.	Per cent	First analysis	Second analysis	Per cent
Lycium andersonii Gray	18	12	67	3	1	11
Hymenoclea salsola T. & G.	8	4	50	1	1	12
Eurotia lanata (Pursh.) Moq.	17	8	47	0	0	0
Tetradymia spinosa H. & A.	30	12	40	2	2	7
Grayia spinosa (Hook.) Moq.	29	8	28	1	2	5
Yucca brevifolia Engelm.	7	2	28	0	0	0
Ephedra nevadensis Wats.	24	5	21	8	9	36
Stipa speciosa Trin. & Rupr.	35	3	9	5	12	24
Acamptopappus sphaerocephalus (Harv. & Gray) Gray var. *hirtellus* Blake	75	2	3	13	14	18
Eriogonum sp.	18	0	0	4	1	14
Mirabilis bigelovii Gray	6	0	0	1	0	8
Opuntia echinocarpa Engelm. & Bigel.	0	.....	.....	.....	1	.....
Dead shrubs	54	3	6	11	12	20
Free growing	.....	0	.....	0	1	.....
Total number	321	59	.....	49	56	.....

in connection with the place where it was growing. It will be seen that there is a very close correlation between the frequency of occurrence with a given shrub (see table 1) and the size of *Rafinesquia*. This is an independent indication that the frequency of occurrence of this plant is due to better growing conditions.

If we ask now what conditions are responsible for the occurrence of certain annuals with certain shrubs, the following points should be considered.

(1) The shrub may offer more favorable microclimatic conditions than are found in the open. If this were the case, then we would expect that all shrubs of a given size and foliage density would be equally suitable for given annuals. This is definitely not the case, and shrubs of comparable size and density, such as *Franseria* and *Encelia*, are very different in their aptitude for harboring annuals.

(2) The same thing can be said of the effect of shrubs on the accumulation of seeds by wind, etc. There is generally a preference on the part of the annuals for one side of the shrub, where they will be found growing in greater abundance. This is especially marked with the larger shrubs, and Dr. J. van Overbeek attributes this to the prevailing winds which cause an accumulation of organic material, such as fallen leaves, at the leeward side. This effect of wind, however, does not influence in any way the occurrence of certain annuals with particular shrubs.

(3) One finds many small clusters of shrub-associated annuals growing apart from shrubs, but almost invariably one will find in such clusters the remnants of a shrub in the center of such a cluster. In many clusters it is still possible to identify the dead shrub; and it is most interesting to note how, for instance, the soil around *Encelia* becomes a much better growing medium for *Phacelia* or *Rafinesquia* once the shrub is dead. This observation invalidates the argument that the physical influences of the shrub, such as shading, condition the occurrence of the annuals. That shading is not an important physical factor for the occurrence of many shrub-associated annuals is also evidenced by the fact that cacti, such as *Opuntia echinocarpa* Engelm. & Bigel., offer excellent growing conditions for *Rafinesquia*, e.g.

(4) In some localities the correlations between the shrubs and plants are much more pronounced than in others. This was noted, for example, for *Rafinesquia;* whereas near Barstow not a single specimen was found apart from *Franseria*, in Borego Valley it was, although closely associated, not exclusively found with *Franseria;* and near the station "Ocotillo" most of the *Rafinesquia* grew outside *Franseria* bushes. This was obviously caused by recent floods. Near Barstow the surface of the desert had been undisturbed for many years, and very few plants of any sort grew in the open away from shrubs. Near "Ocotillo" opposite conditions existed. Floods had recently disturbed the surface, and organic material was distributed all over the sur-

face of the desert. In this locality, not only *Rafinesquia,* but a number of other plants commonly associated with shrubs were growing free. This is the same phenomenon that is observed along roads where scrapers have piled up a ridge of scraped-off sand still containing organic material, which is thoroughly mixed. On those ridges, not only shrub-associated annuals grow, but also certain fungi, such as *Podaxon.*

Vegetation in Borego Valley. With the help of Dr. C. Epling, Dr. J. van Overbeek, and Mr. P. Gorham, a sociological study was made of the vegetation of the bajada at the mouth of Palm Canyon. This is a gently sloping field of sand mixed with gravel and occasional large stones. Being an alluvial fan, it is of very recent origin, but the surface apparently had not been disturbed for several years. To get an idea of the general distribution of the flora in this area, all the plants in a square of 8×8 meters were recorded. Within the chosen square which was typical of the region occurred one large shrub, *Hyptis emoryi* Torr., with a crown of 2 meters in diameter, 14 well-developed specimens of *Encelia farinosa* Gray, each with a diameter of approximately 1 meter, and 1 young specimen of the same species, 8 well-developed *Hymenoclea salsola* T. & G. and 2 young specimens. *Nemacladus ramosissimus* Nutt. covered almost half the surface of the bare soil between these shrubs, but because of its thread-like stems and "protective coloration" only close observation revealed its presence. Among the larger annuals *Phacelia distans* and *Langloisia schottii* (Torr.) Greene were the most common, covering about 15 per cent of the surface of the area. The *Phacelia* was growing exclusively with *Encelia* and *Hyptis; Langloisia* was scattered in between the shrubs. Next in abundance were *Chaenactis fremontii* Gray, *Filago arizonica* Gray, and *Bromus rubens* L., covering from 2 to 5 per cent of the surface of the square. Less abundant were *Malacothrix californica* DC., *Euphorbia polycarpa* Benth. var. *hirtella* Boiss., *Mimulus bigelovii* Gray, *Nama demissum* Gray, *Oenothera leptocarpa* Greene, *O. micrantha* Hornem. var. *exfoliata* (Nels.) Munz, *Emmenanthe penduliflora* Benth., *Salvia columbariae* Benth., and *Lotus tomentellus* Greene, each represented by 10 to 40 specimens. Still fewer plants occurred of *Rafinesquia neomexicana, Calyptridium monandrum* Nutt., *Monoptilon bellioides* (Gray) Hall, and *Tillaea erecta* H. & A. Over a larger area, of course, more species were encountered within this region, and table 1, column 1, summarizes the total number of shrubs counted within a transect. This gives a good idea of the frequency of these shrubs on the part of the bajada studied. In addition to the annuals enumerated above, about 15 others were found in this area.

As mentioned above, a number of plants grow predominantly in the open spaces between the shrubs. To these belong: *Mimulus bigelovii, Filago arizonica, Nama demissum, Nemacladus ramosissimus, N. longiflorus* Gray,

Lotus tomentellus, smaller specimens of *Chaenactis fremontii*, *Euphorbia polycarpa*, *Oenothera micrantha*, *O. brevipes* Gray, *Monoptilon bellioides*, *Achyronychia cooperi* T. & G., *Lepidium lasiocarpum* Nutt., *Tillaea erecta*, *Chorizanthe brevicornu* Torr., *Cryptanthe micrantha* (Torr.) Johnston, *Bromus rubens*, and *Eriogonum reniforme* Torr. & Frem. Some of the other plants which are more commonly found near shrubs have been entered in table 1. Columns 2–7 give the percentage of shrubs harboring these annuals. These percentages show that *Phacelia* is common around practically all shrubs, but that with *Dalea*, *Larrea*, and living *Encelia*, fewer specimens are found. Since the abundance of the various shrubs is not the same, the data have been calculated also in a different way, and in columns 8–13 the percentage of the total number of each annual found is entered in connection with the shrub. A critical examination of this table shows that important differences exist in this region between various shrubs as far as their aptitude for harboring different annuals is concerned. As a first example should be mentioned the difference between living and dead *Encelia*. With both *Phacelia* is fairly abundant, but *Malacothrix*, *Emmenanthe*, and *Rafinesquia* are far more common with dead than with living *Encelia*. Whereas *Franseria* is an equally good habitat for *Phacelia* as is dead *Encelia*, it is far poorer for *Emmenanthe* but equally good for *Rafinesquia*. The last columns show that about half of all specimens of *Rafinesquia*, for instance, occur with *Franseria;* whereas only 6 per cent of all *Emmenanthe* plants are found near this shrub.

Under slightly different soil conditions some differences in the specificity of shrubs for certain annuals may be found, but as a general rule it can be said that the less disturbed the soil surface, the more pronounced are the correlations between annuals and shrubs. In a number of other localities less extensive sociological analyses were carried out.

The Mojave desert. In a region north of Kramer the terrain is slightly hilly, with rounded hills of decomposed granite in between the wide washes. Only the hills were investigated by noting the shrub-associated annuals in a transect. Table 3 presents some of the data for this region. The behavior of two *Caulanthus* species, namely, *C. lasiophyllus* and *C. cooperi*, is extremely interesting. The latter species grows quite consistently within shrubs of *Franseria*, although mostly only one single specimen per shrub. It grows occasionally with some of the other shrubs but seems to avoid most of them. Whenever it is growing under *Larrea*, specimens are very small, and only a few times did I see a small specimen growing out in the open. The behavior of *Caulanthus lasiophyllus* is practically complementary to that of the first-named species. It is found only very occasionally with *Franseria*, but is the constant companion of *Larrea*, and also is found more often in the open.

The behavior of *Phacelia tanacetifolia* differs from both of the preceding species in that it is common both under *Franseria* and *Larrea*.

In a different locality just south of the town of Mojave *Phacelia tanacetifolia* behaved differently. It grew there under 70 per cent of all *Larrea* bushes, whereas it was found under only 2 per cent of *Franseria*, which is also quite common there. Only a few plants grew free, but they were extremely short and small, less than one fourth of the size of those growing under the *Larrea*.

Just south of Barstow *Rafinesquia* was found again in limited numbers. It was found there in one transect with 8 of the 50 *Franseria* bushes, whereas under none of the 14 *Larrea*, 3 *Grayia*, and 2 *Mirabilis* was it observed. Near Adelanto *Rafinesquia* was found with 9 per cent of all shrubs of *Atriplex lentiformis* (Torr.) Wats. (?), with 4 per cent of the *Franseria dumosa* Gray, and twice it grew with a dead plant. In not a single place was it found growing free or with *Larrea*. This behavior is similar to that of *Rafinesquia* observed in the Borego desert.

Farther east three localities, two near Ludlow and one south of Amboy, were visited, and the occurrence of *Rafinesquia* was recorded. Table 4 shows the results in a condensed form. Although the abundance of *Rafinesquia* varied greatly, in general the figures agree: Whenever *Krameria* occurs, one has a better than 1 : 3 chance that *Rafinesquia* will be present. For *Franseria* the figures vary more, but in every instance it is a poorer habitat for *Rafinesquia* than *Krameria* is, and twice as good as *Larrea* is. In this connection it should be pointed out that the shrubs of *Larrea* are many times larger than are those of *Franseria*, so that on a purely statistical basis the chance that *Rafinesquia* would occur under *Larrea* is many times greater than under *Franseria*. Since there are also many more other annuals growing under a *Larrea* than under a *Franseria*, there is more chance that one of those others has a favorable influence on *Rafinesquia*, so that the preference of the latter for *Franseria* is far more pronounced than the mere figures in the table indicate.

Another very clear correlation between annuals and shrubs is presented by the occurrence of *Delphinium parishii* Gray in the Mojave desert. Table 5 condenses the data of the observations near Palmdale. The shrubs have been arranged in the order of decreasing occurrence of *Phacelia distans*. For *Delphinium* especially those shrubs are most suitable which do not favor *Phacelia*. Only once were these two annuals found growing together within the same shrub. By independence this would have been expected about 9 times. This proves again, that although the presence of shrubs as such is essential for the occurrence of a number of desert annuals, there is also a strong specificity on the part of certain annuals for certain shrubs.

In a different locality—the hills south of Kramer—*Delphinium* was also quite common, but there half the specimens (70) grew free, in between shrubs. Almost invariably these specimens were smaller than those growing with shrubs. The latter grew predominantly with *Acamptopappus sphaerocephalus* (Harv. & Gray) Gray (47 specimens, with 12 per cent of all shrubs), a few with *Franseria dumosa* (2 per cent), *Aster abatus* Blake (3 per cent), *Eurotia lanata* (Pursh.) Moq. (1 per cent), and 10 plants had developed with dead shrubs.

To get a complete picture of the distribution of plants over the surface of a given desert area, the germination and later growth of the shrubs must also be considered. I have only casual observations to mention. Many of the desert shrubs germinate and develop into young plants only once every few years, when the climatic conditions have been favorable. Even in those favorable years, the number of seedlings is limited. But it is found that *Franseria* seedlings are most often found in open spaces, not associated with pre-existing vegetation. The same seems to be true for *Larrea*. On the other hand, I saw seedlings of *Encelia* growing under other shrubs, such as *Franseria*, so that the common association of *Encelia* and *Franseria* bushes seems to be conditioned by the occurrence of the latter.

On an old lava flow near Amboy seedlings of both annuals and perennials were observed. Sand had filled cracks and depressions in the surface. This sand holds a certain amount of moisture during winter, enough for a few months' growth but not enough to carry any plants through the summer. These lava flows were covered with numerous plants of *Geraea canescens* T. & G., which can grow on any well aerated soil which has not previously had a covering of vegetation. Between the *Geraea* a number of seedlings of *Larrea tridentata* Cov., *Franseria dumosa*, *Atriplex hymenelytra* (Torr.) Wats. and a few other *Atriplex* species, and *Suaeda fruticosa* Forsk. (?) were found; all perennials, which are often found free-growing on the desert. Few annuals had established themselves; in addition to *Geraea*, a few specimens of *Nama demissum*, *Achyronychia cooperi*, and *Cryptanthe* sp. were found, but none of the species commonly associated with shrubs. Thus the vegetation of the lava flow confirms the previous deductions: many shrubs can establish themselves in the desert without association with other plants. The same is true for annuals commonly found in open spaces between shrubs. But the annuals which are normally found only near shrubs were completely lacking on this lava flow; their association with shrubs is essential for their germination and growth.

Another phytosociologically interesting case is presented by the refuse dumps of the harvester ants (*Pogonomyrmex*). These ants collect the fruits of many plants, mostly annuals, which they pick when almost ripe, and trans-

port to their nests. There the fruits are opened, the seeds extracted and stored, and the carpels are thrown outside the nest in semi- or complete circles outside the ring of excavated sand around the nest opening. These refuse heaps are interesting for their flora, and can be recognized one or more years after the nest is abandoned. In such cases a circle of plants will still surround an open space, although it was never occupied by a shrub. The species of annuals occurring in these refuse dumps are different from those of other groups of annuals. In general *Erodium cicutarium* (L.) L'Her. dominates. Even when no other *Erodium* is found in the neighborhood, one may still find a few specimens near the ants' nest. Many plants, which are otherwise found only near shrubs, grow in the refuse dumps, such as *Salvia columbariae, Ellisia micrantha* (Torr.) Brand, *Stephanomeria exigua* Nutt., and around a few nests even *Phacelia distans* was present. One will find the ants carrying the fruits of these plants, so that not only their distribution, but also the accumulation of humus, which is a prerequisite for their growth, is due to the ants. Certain other plants, although growing free on open spaces, are much more frequent near ant nests, such as *Plantago insularis* Eastw. var. *scariosa* Jepson, *Euphorbia polycarpa, Eriogonum* species, and *Langloisia schottii*. This is not due to accumulation of humus since these plants do not grow more abundantly near shrubs. Therefore this must be due to the seed collecting by the ants, and to the occasional oversight of a filled seed pod by the workers. The association of these plants with ant nests is comparable with the epiphytic ant gardens of the tropics (Ule 1904, Docters van Leeuwen 1929), although several of the epiphytes are found almost exclusively in ant nests.

DISCUSSION

By stressing the relationship between certain plants in the desert it is not intended to imply that this is the only or the most important factor in the occurrence of desert annuals. It has been mentioned that many plants are apparently completely independent of other plants and grow most luxuriantly where no shrubs or perennials are established. Nor does this note give all interesting relationships which occur. Almost every trip to the desert brings evidence of other correlations. The frequent occurrence of many annuals with desert shrubs has been previously observed, as evidenced by the habitat description of *Rafinesquia neomexicana*, for example, "Desert Mesas, common among bushes" (Jepson 1925); "Weak-stemmed plant, growing in the shade of shrubs and frequently climbing up through them" (Jaeger 1940). Other quotations from Jaeger run as follows:

Phacelia distans: "common under cat's claw and ironwood."

Phacelia tanacetifolia: "often growing about the bases of creosote or cat's claw bushes."

Caulanthus cooperi: "often growing in the protection of shrubs."
Chaenactis fremontii: "frequent about the bases of creosote bushes."
These descriptions show that in addition to the correlation of these annuals with shrubs, Jaeger had even noticed that certain bushes were preferred by certain annuals, but to most of the local taxonomists the specificity of the occurrence of these annuals seems to have been unknown.

If we attempt to summarize, the following conclusions are the logical outcome of the above observations:

In the first place, detritus from most shrubs provides a necessary factor for the growth of all shrub-associated annuals, both for the less specific species, such as *Chaenactis fremontii*, as well as for the specific *Rafinesquia*. For whereas some shrubs in general do not favor the growth of an annual, after their death they become a much better medium (see, e.g., *Malacothrix*, *Emmenanthe*, and *Rafinesquia* in table 1; their occurrence is increased more than fivefold with dead *Encelia* as compared with living *Encelia*).

In the second place, there is a specific effect of shrubs, which must be ascribed to specific materials given off by them. These materials seem to be produced especially by the living shrub and they determine the specific occurrence of definite annuals. No guess as to the nature of these materials will be given; this can safely be postponed until experimental evidence is available.

In the description of the occurrence of desert annuals it has been pointed out above, that certain physical factors cannot explain the specific occurrence of shrub-associated annuals. For example, shade is not the determining factor, since dead shrubs, with practically all branches gone, provide sometimes a more favorable habitat than living shrubs. If the shrubs acted by virtue of their influence on the water content or water holding capacity of the soil, all shrubs could be lined up in a series of increasing suitability as habitat for annuals, and this series should be the same for different annuals. This is definitely not the case. Besides, by simple reasoning one would expect the shrub to be in water competition with the annuals growing within its confines, and thus inhibit rather than enhance its growth. However, this problem cannot be settled by reasoning, but needs an experimental approach. The preceding observations only serve to provide a factual basis for future experiments, which should be carried out both in natural surroundings and in the laboratory.

It seems likely that the observed phenomenon is widespread and very common in plant communities. In all sociological studies of vegetation made by the author, such a relation between various members of a community was found, and it seems only necessary to point out the phenomenon, to find it in many other instances. Almost every plant-sociological analysis contains

numerous indications that a causal relationship exists between the occurrence of the various members of a plant association; an analysis of the topographical relationships between these plants within the association would probably furnish very strong additional evidence. As soon as a number of such cases have been analyzed the proof of the causality in their mutual occurrence can be given by cultural experiments.

This short note is not the place to discuss more fully the implication of the existence of causal relationships between individual plants. Nevertheless, it should be pointed out that the advantages of rotation of crops might be attributable to such mutual influences. Although it is not usually feasible to mix crops, it is common practice to let one follow the other (crop rotation), and some chemical influences of one crop might be carried over in the soil to the next crop. In many instances a distinct advantage of certain cover crops or shade trees (often leguminous plants) on the main crop has been noted, a beneficial effect which exceeds the effect attributable to nitrogen fixation by the leguminous cover crops. The opposite is also known; the presence of *Imperata*, a common grass in Java, may endanger not only the production but even the life of plantation trees such as *Hevea*.

In lakes, ponds, and ditches distinct correlations between various plants and animals exist. In those localities chemical inter-relations obviously play a major part. It is most interesting to note that lakes in different regions under different climatic conditions may contain the same algal communities. Beyerinck (1927) points out that the same 2 algal biocoenoses which are common in the pools of the heather vegetation in the northern parts of the Netherlands are found in essentially the same floristic composition in the ponds in the southern part of the Netherlands. It seems that only a direct influence of the partners of such an algal community on each other can explain their sociological distinctness.

SUMMARY

Wherever lack of precipitation prevents a continuous cover of vegetation in Southern California, the dependence of certain annuals upon the presence of specific shrubs becomes evident. Especially for *Rafinesquia neomexicana* it was shown that its occurrence depended upon the presence of *Krameria* and *Franseria* in the first place, *Ephedra*, *Opuntia*, and *Hymenoclea* in the second place, and *Larrea* and *Encelia* in the third place. The aptitude of these shrubs for providing good growing conditions was also evidenced by the fact that the more frequently *Rafinesquia* occurs with a given shrub, the larger are the specimens growing in that shrub. Similar relationships were found for *Caulanthus lasiophyllus*, *Caulanthus cooperi*, *Phacelia distans*, *Phacelia tanacetifolia*, *Malacothrix californica*, *Delphinium parishii*, and a

few other annuals. Other groups of annuals do not depend upon shrubs or organic material for their growth. Many of these are found in great abundance in open spaces in between shrubs.

Literature Cited

Beijerinck, W. 1927. Over verspreiding en periodiciteit van de zoetwaterwieren in Drentsche heideplassen. Diss. Wageningen, Holland, **1927**: 1–211.

Docters van Leeuwen, W. 1929. Kurze Mitteilung über Ameisen-Epiphyten aus Java. Ber. Deuts. Bot. Ges. **47**: 90–99.

Jaeger, E. C. 1940. Desert Wild Flowers. Stanford University.

Jepson, W. L. 1925. A manual of the flowering plants of California. Berkeley.

Kooper, W. J. C. 1927. Sociological and ecological studies on the tropical weed-vegetation of Pasuruan (the island of Java). Rec. Trav. Bot. Néerl. **24**: 1–225.

Ule, E. 1901. Ameisengärten im Amazonas-Gebiet. Engl. Bot. Jahrb. **30**: 45–52.

Went, F. W. 1940. Soziologie der Epiphyten eines tropischen Urwaldes. Ann. Jard. Bot. Buitenzorg **50**: 1–98.

BULLETIN OF THE TORREY BOTANICAL CLUB
69(2): 115–129 FEBRUARY, 1942

SECONDARY VASCULAR TISSUES OF THE OAKS INDIGENOUS TO THE UNITED STATES—III. A COMPARATIVE ANATOMICAL STUDY OF THE WOOD OF LEUCOBALANUS AND ERYTHROBALANUS[1]

SIMON WILLIAMS[2]

(WITH FIFTEEN FIGURES)

Leucobalanus and *Erythrobalanus* have been redefined previously on the basis of the correlation existing between leaf-form and the structure of the late-wood pores in the secondary xylem (18). The nature and distribution of tyloses among *Quercus* species has been discussed in relation to these newly proposed subgeneric limits (19). The controversial comments stimulated by these initial reports activated a more comprehensive anatomical study of the two subgenera to determine in what other respects the red and white oaks, as recognized herein, differ from one another. To this end, the various cell and tissue types present in oak wood are discussed separately below.[3]

CELL TYPES AND TISSUES STUDIED

Early-wood Vessels. The white oaks are typically ring-porous with the exception of the shrubby species, *Q. sadleriana* R. Br. Campst. The early-wood zone ranges from 1- to 4-seriate, and in a given species may exhibit this entire range. In general, in the more slowly growing species, the larger pores are more nearly arranged in a uniseriate row, and those further out in the early wood are considerably reduced both in number and size. The red oaks are similar in these respects, with the exception that the woods may range from typically ring-porous to diffuse-porous. Also, the pores of the red oaks exhibit a less abrupt transition in size from early wood to late wood.

The shape of the pores is similar in both groups, ranging from nearly orbicular to oval or narrowly elliptical. The radial axis is generally longer than the tangential, although it is not so conservative in its variation as the latter.

In typically ring-porous species of the two subgenera, the wall of the early-wood pores ranges between 2 and 4 microns in thickness. Among the

[1] The information incorporated in this paper has resulted from research by the author while a member of the Department of Wood Technology, New York State College of Forestry, Syracuse, N. Y.

[2] Research Technologist, Bureau of Industrial Chemistry, University of Texas, Austin, Texas.

[3] One hundred and thirty-five samples, covering thirteen species of *Leucobalanus* and thirty-two species of *Erythrobalanus*, were included in this study.

diffuse-porous species, the early-wood pores are somewhat thicker walled (3–6 microns) and grade more gradually into the thick-walled late-wood pores (all the diffuse-porous species are red oaks).

No distinction between the two subgenera can be based either on the length or the shape of the vessel-members. The early-wood vessel-members are usually short, but occasionally may be classified as long; the xerophytic and shrubby species have shorter elements. The early-wood vessel-members are from 50 to 125 microns shorter, on the average, than those in the late wood; they may be tailed or not; if present, the tail is usually short and is either pointed or tapers to a blunt apex.[4] The perforation plates are simple and horizontal or nearly so. Three types of pitting are common throughout the vessel-members of the early wood of all species, viz.:[5]

1. Pits leading to vasicentric tracheids (fig. 1). This type of pitting is the most frequent and may extend entirely over both the radial and tangential walls. Usually, the vermiform impressions of the tracheids are present; when they are, the pitting is restricted to these areas. The pits are large and round, and are provided with an elliptical to oval, included aperture. They vary in diameter from 4 to 12 microns. Not infrequently they appear punctate in surface view, resembling vestured pits in every way. However, this feature is sporadic in *Quercus*, and as has been pointed out (2), it is the result of artifacts produced during post-mortem changes in the cells or during the transformation of sapwood into heartwood. No structural evidence could be found to contradict Bailey's statement on this matter.

2. Ray-crossing pits (fig. 1). Ray-crossing pits are restricted to pit fields. The number and size of the pits within a pit field varies according to the size of the field from 3 to 7 or more. The pits are usually simple, but may be bordered. They are extremely variable in shape, ranging through round, oval, twisted-elliptical, rectangular, etc., and in alignment they exhibit fully as wide a fluctuation. The long axis may be as much as 30 or more microns; in general, the larger the pore, the larger the pit field, and the more conspicuous the pits. This is not absolute for the oaks.

3. Pits leading to longitudinal parenchyma. These are rounded, bordered pits with a broad, oval, included aperture; they are noticeably smaller (from 3 to 6 microns in diameter) than the intertracheary pits. Pits of this type may be recognized by their tier-like arrangement in pit clusters, as seen in macerated material.

---

[4] Vessel members measured and described after the methods suggested by Chalk and Chattaway (5, 7).

[5] The vessels are always solitary in *Quercus;* if intervessel pitting occurs, it is restricted to the overlapping tails of members of the same vessel, and resembles in every way the pitting between a vessel and a contiguous vasicentric tracheid.

Late-wood Vessels. The structure and distributional frequency of the late-wood pores provide the only absolute means, on the basis of wood anatomy, of distinguishing *Leucobalanus* from *Erythrobalanus* (18). Abromeit (1), in 1884, first attempted to classify *Quercus* species on the basis of wood anatomy, depending largely upon variations in frequency and cell wall thickness of the late-wood pores to delimit his various groups. Unfortunately, probably through insufficient sampling and coarseness of technique, Abromeit made several errors, such as classifying *Q. wislizenii* A. DC. with those oaks having thin-walled late-wood pores and utilizing extremely variable characters such as pore frequency, pore size (vaguely defined as small, large, etc.), and the degree of lateral coalescence of the radially aligned late-wood pore groups. Because of these various factors, the subdivisions created by Abromeit could not be recreated by examination of new material, nor do these subdivisions adhere strictly to the subgeneric limits defined either by Williams or other workers in this field. Further, Abromeit did not include in his study any of the eight controversial species which Williams has shifted from *Leucobalanus* to *Erythrobalanus*. The work of Abromeit, while of historical significance, cannot be considered as bearing directly upon the new classification of *Quercus* species brought out in this current series of reports on the wood anatomy of oak species native to the United States.

A summation of the differences which are of diagnostic significance follows:

The late-wood pores of white oaks are characterized as follows:

A. *At low magnifications (up to 10×)*

1. Minute, in the majority of species barely distinguishable as distinct openings; when visible distinctly angled and thin-walled; extremely numerous and so crowded in radially aligned, flame-shaped patches that they cannot be counted.

B. *At high magnifications (50× or more)*

1. Thin-walled (under 3 microns)
2. Distinctly angled (more or less polygonal)
3. Very numerous (ranging from 30 to 125 or more per mm.^{2}, for average growth rates generally 40 to 70 per mm.^{2})

The late-wood pores of red oaks are characterized as follows:

A. *At low magnifications (up to 10×)*

1. Usually distinct with a hand lens, appearing as rounded, thick-walled orifices, which are quite widely spaced (and hence easily counted) and more or less radially aligned.

B. *At high magnifications (50× or more)*

1. Thick-walled (3 to 10, average 4 to 7 microns).
2. Rounded or oval (the outer wall obscurely angled).
3. Not numerous (relatively), ranging from 8 to 25 per mm.^{2}, for average growth rates generally 10 to 16 per mm.^{2} (this figure did not exceed 30 in any sample studied, in spite of the fact that every effort was made to obtain the largest figure possible in certain test cases).

The late-wood vessel-members range from short to long. Although *Leucobalanus* and *Erythrobalanus* cannot be separated on this basis, the white oaks tend to have slightly longer members, with longer, more tapering tails than those of the red oaks. In the latter, the vessel-members taper more abruptly to an acute or acuminate apex. In both groups, the end walls are oblique and the perforation plates simple, except that scalariform plates may occur in the smaller vessels of the live oaks. This feature was not observed during the present investigation, but has been reported from different sources (1, 14, 17). The pitting on the walls of the late-wood members is similar in every way to that found on the early-wood members.

Fibers. The fibers of the oaks exhibit no departures of subgeneric significance (fig. 2). They are intermediate between typical fiber-tracheids and libriform fibers found in other woods, and except for length are remarkably uniform throughout the genus. Thick-walled fibers are the rule, although thin- and very thick-walled fibers occur occasionally.

The shape of the fibers is best determined from macerated material; they are elongated, tapering elements which frequently possess forked or jagged-toothed edges. In cross-section, the fibers are generally hexagonal, but owing to pressure occasioned by the enlargement of the vessels behind the cambium, they depart from this shape considerably. The tangential diameter varies from 6 to 25 (average 10–16) microns, and the walls vary in thickness from 4 to 10 microns. Not infrequently the inner wall (next to the lumen) is gelatinous, but this feature is common to both subgenera and hence is of no diagnostic importance. Large masses of gelatinous fibers occur in some oaks (*Q. lyrata* Walt.) as a constant feature; in others, fibers of this sort are abundant but not massed or may be wanting entirely. The gelatinous wall, when present, is usually thick, constituting from one-third to one-half or more of the cell wall.

The interfiber pits, although bordered, are so small that the classification of the fibers on this basis is of no value except at extremely high magnifications. They are round, possess slit-like excluded apertures, and are approximately 4 microns in diameter. Interfiber pitting is rare on the tangential walls and sparse on the radial walls (occasionally moderately abundant over a small area).

Gummy infiltration is common in the fiber lumina. It often assumes the form of spindle-shaped or rod-like bars across the cavity which simulate the cross-walls of septate fibers.

Several statements relative to the variation in the fibers of oak wood may be made here, even though they are of no significance diagnostically. Although in any one species both long and short fibers occur in different samples and in the same sample, the shrubby and xerophytic oaks, as groups,

have shorter and finer fibers than the remaining species; this observation agrees with the work of Bailey and others (3, 15, 16). This phenomenon has probably resulted from the adaptation of these species to edaphic and climatic factors, and although it was undoubtedly conditioned by the environment, it has now become fixed, that is, it has now become a specific feature for the oaks in question. Mell (11), working with black walnut (*Juglans nigra* L.), has pointed out that the faster-growing trees of this species on better sites have longer elements (fibers) than those growing on poorer sites, with resulting slower growth rates. There is no indication that this holds for the oaks; except under very unusual conditions (xeric habitat), no variation in fiber length can be anticipated in individuals of the same species grown under optimum and unfavorable conditions. Nor does suppression in oaks have any observable effect on fiber length, contrary to the results of MacMillan (10) working with red spruce (*Picea rubra* Diet.). MacMillan indicates that suppressed trees of this species have shorter elements than free-grown trees. Although the field data covering the samples of oak studied were meagre for some species, there is no indication that oaks react similarly to red spruce. Suppression usually implies slow growth (although slow growth does not necessarily imply suppression), and fiber length in oak appears independent of ring width.

Longitudinal Parenchyma (figs. 4, 5, 6). The arrangement of longitudinal parenchyma is similar in both subgenera; in the great majority of species it is metatracheal, with occasional cells terminal or contiguous to the vessels (paratracheal). The latter type, after the reasoning of Chalk (6), is probably incidental owing to the irregular course of the bands of metatracheal parenchyma.

The factors causing variation in the frequency distribution of parenchyma are so complex that they cannot be evaluated with any real accuracy. Frequency would, therefore, be too uncertain a feature to be used in defining subgeneric limits, or in aiding in the recognition of any congeries within subgenera. Nevertheless, there does seem to be a vague indication of group relationships, based on frequency, that is worthy of note. *Erythrobalanus,* especially the live oak group, appears to have a greater amount of parenchyma, on the average, than *Leucobalanus.* The species studied are listed below, with the average obtained for the number of parenchyma cells per mm.^{2} of late wood, exclusive of the area occupied by the pores.[6]

The bands of zonate parenchyma are commonly 1- or 2-seriate in the white oaks, and seldom anastomose. The increased parenchyma volume of the red oaks is manifested by wider bands (2 to 4 or more seriate), and the

[6] These averages are not calculated statistically, but each is the average of ten measurements from each sample of every species.

Number of Cells per Square Millimeter of Longitudinal Parenchyma

Leucobalanus

Species	*no. mm.²*
Q. alba	325
Q. bicolor	300
Q. durandii	560
Q. garryana	400
*Q. breweri**	675
Q. lobata	490
Q. lyrata	
Q. macrocarpa	390
Q. muhlenbergii	360
Q. prinus	305
*Q. sadleriana**	310
Q. utahensis	390

Erythrobalanus

Live Oaks

Species	*no. mm.²*
Q. agrifolia	640
Q. arizonica	620
Q. chrysolepis	765
*Q. dumosa**	690
Q. engelmannii	475
Q. emoryi	540
Q. laurifolia	530
Q. myrtifolia	595
Q. oblongifolia	435
Q. hypoleuca	650
*Q. reticulata**	545
Q. virginiana	610
Q. virginiana geminata	620
Q. wislizenii	475

Deciduous Oaks

Q. borealis maxima	375
Q. catesbaei	530
Q. cinerea	595
Q. coccinea	355
Q. douglasii	855
Q. ellipsoidalis	460
Q. ilicifolia	555
Q. imbricaria	390
Q. kelloggii	600
Q. marilandica	600
*Q. morehus**	575
Q. nigra	410
Q. palustris	370
Q. phellos	435
Q. falcata	490
Q. falcata triloba	510
Q. falcata leucophylla	410
Q. shumardii	420
*Q. vaccinifolia**	615
Q. velutina	410

*Shrubby species.

frequent coalescence of these. Among the live oaks, in which parenchyma is unusually abundant, the zonate arrangement is obscured.

In all other respects, the parenchyma of both groups is identical. In cross-section, the cells are thin-walled (under 4 microns) and range from

oval to polygonal due to tissue distortion occasioned by the enlargement of the vessels behind the cambium. In this plane, they are distinctly larger than the fibers, measuring from 10 to 30 or more microns in tangential diameter. In longitudinal section, the strands of parenchyma are composed of from 2 to 20 or more units, the terminal cells tapering to a point. The pits between cells are simple and abundant, and when seen in face view show a tendency to cluster into small groups of from 2 to 4 in pit fields. Crystals may be absent, sparse, or very abundant.

Tyloses. The nature of the tyloses in the two subgenera of *Quercus* has been previously discussed and needs no further consideration in this paper (19).

Broad Rays. The broad rays of *Quercus* are either aggregate or compound. *Leucobalanus*, with the exception of the shrubby forms, has true compound rays (figs. 10, 11). Both true compound rays and aggregate rays characterize *Erythrobalanus*, but only among the live oaks do aggregate rays become a constant feature of the mature wood (figs. 12–15). In this regard, the live oak group is more strikingly distinguished by the nature of the broad rays than by any other structural feature with the possible exception of their diffuse-porousness. The tendency to possess aggregate rays, taken together with the exceptional width, shortness along the grain, blunt ends, and high frequency of these structures, sets these species off as distinct from other oaks. This composite of features was noted by Sudworth and Mell (17), who state "Evergreen oaks, and particularly very slow growing species or those growing on dry soil, develop low and wide rays, which have blunt ends above and below."

As with longitudinal parenchyma, the size and frequency distribution of the broad rays seem to indicate certain group relationships. However, here too the inherent range of variation, either by species or by groups, is greatly complicated by the influence of the environment; until comprehensive studies can be made on each individual species throughout its entire range, these factors cannot be truly evaluated, and the significance of differences must remain in doubt. There is, of course, no reason to assume that the oaks do not follow the general laws of ray size and ray distribution (4, 8, 12), which may be listed as follows:

1. Ray volume is at a maximum in the root and in the crown; in the former because of increased size of the rays, in the latter because of an increase in their number.

2. Ray volume increases with age up to a certain point, after which it remains more or less stationary.

3. The larger the crown and the greater the physiological activity, the greater the ray volume.

4. Ray height decreases from the stump upward, and generally increases from the pith outward (Büsgen and Münch 4, state that in some conifers the ray height is greatest in the first ring, decreasing thereafter for a period, and again increasing with old age).

Granting that these rules are in force among the oaks, there is still no indication of the effect of external factors in regulating the quality and quantity of the changes within a species or within an individual of a species. The rules may be valid, but they offer no clue in determining the specific nature of apparent differences in size and distribution. The only hint as to the reaction of the oaks to changes in site and locality lies in the work of Myer (13) on *Q. alba* L. This author, after studying the effect of range, habitat, and position in the tree on the structure and strength of this species, concludes, in relation to the broad rays:

"The height of the compound ray was found to be about 50% greater in specimens from the Ohio Valley and Appalachians than it was in those specimens from northeastern United States. Little weight can be attributed to this difference, however, since it must be contrasted to a 90% average intra-regional variation. Within a single tree the maximum deviation in ray height was found to be as high as 60% in passing from stump to merchantable top. The highest rays were found in the stump wood and from this point their height decreased gradually upward. Radially in the trunk, the rays became slightly taller as they progressed from the pith outward but the percentage change of 30% was less than it was lengthwise in the bole. Although these figures show where the highest rays are likely to occur, it nevertheless is quite evident that range exerts no constant influence on this dimension which appears to be more dependent upon individual differences and upon the region in the range where the tree is growing."

If the variation exhibited by *Q. alba* is indicative of specific instability, then the range between different species is liable to be even greater and less applicable in diagnosis. Therefore, no attempt was made to utilize the differences exhibited between species in the character of the broad rays, aside from certain broad generalizations, as follows:

1. As stated previously, the evergreen habit favors short, broad rays (17), which exhibit a distinct tendency toward the aggregate condition.

2. Dry site, in both subgenera, results in a wider type of ray, but has no constant influence on ray height.

3. The effect of abundant moisture is exceedingly contradictory. Sudworth and Mell state "the deciduous oaks, growing in moist alluvial soils, develop high and narrow pith rays." In general, this is true, but increased moisture may influence ray width in both directions. *Q. bicolor* Willd., for example, has broad high rays, in contrast to the narrow rays developed in *Q. phellos* L. and *Q. lyrata* Walt.

4. As a group the red oaks have shorter, more slender rays, and a higher ray volume than the white oaks (referring to the broad rays). This is in general agreement with the work of Myer (12) and Hartig and Eichler (Büsgen and Münch, p. 116), and although no ray volume measurements were made, the statement is given further substantiation by the ray frequency counts that were made. For *Leucobalanus*, the average range for the number of rays per square inch of tangential surface was 20 to 34; the entire range 10 to 60. Among the red oaks, the average range was 30 to 65; the entire range 25 to 115. There was considerable overlapping between the two subgenera, as is indicated by the breadth of the spread through which they both passed. The live oaks were all high (with the exception of those samples of *Q. chrysolepis* Liebm., in which the state of aggregation is so weak that the broad rays are inconspicuous), ranging from 50 up.

Measurements revealed that the average ray height among the red oaks rarely exceeds one-half inch, further that the maximum ray height of the samples studied was 2 inches. Rays over one-and-one-half inches in height are not common. In *Leucobalanus*, while many of the samples fell into the same general range as those of *Erythrobalanus*, an equal number of specimens, especially from such species as *Q. alba* L., *Q. bicolor* Willd., *Q. stellata* Wang., and *Q. montana* Willd., had average ray heights of from one-half to one-and-one-quarter inches, and rays in excess of one-and-one-half inches were common. The maximum observed height was 4 inches. The live oaks had the shortest rays of all, on the average, ranging from one-eighth to three-eighths of an inch, rarely exceeding one-half inch. Longer rays do occur among certain species of live oak, such as *Q. arizonica* Sarg., *Q. dumosa* Nutt., and *Q. virginiana geminata* Small. Frequently, in this group, the influence of ray aggregation extends for a considerable distance along the grain, creating a false impression of high compound rays.

Uniseriate Rays. The uniseriate rays of *Quercus* spp. are valueless for diagnostic purposes, except as they are typical for the genus. They are very abundant, ranging from 75 to 200 or more per mm.^{2} (tangential surface); vary from 2 to 30 or more cells and up to 500 microns in height (average 125–300); are largely homogeneous; are frequently biseriate in part in the immediate vicinity of the broad rays; the cells are oval to rectangular (tangential surface), those in the early wood coarse and more rounded (10–20 microns in tangential diameter) than those in the late wood (7–15 microns in tangential diameter); crystals are infrequent; infiltration is sparse.

Crystals. Crystal formation is common on the wood of all *Quercus* species; it is most abundant in the xerophytic live oaks. In general, the better-site, deciduous oaks have the fewest crystals, the drier-site deciduous

oaks have moderately abundant crystals, and the xerophytic live oaks have excessively abundant crystals. This sequence is variable, any species being capable of exhibiting wide extremes from sample to sample. Although the range of material was inadequate for a thorough test, it may be said as a rule that heartwood contains more crystals than sapwood.

The crystals are largely rhomboidal to hexagonal in section, and are restricted to the parenchymatous tissues. They are most abundant in the broad rays, especially in the neighborhood of the ray ends. The loculi may be solitary or in strings of 2 to 30 or more. The type of crystal formation in oaks has been arbitrarily defined in this paper as sparse (fig. 7), moderately abundant (fig. 8), and excessively abundant (fig. 9).

Color. Not only the tyloses, but the color of the wood has long been used as an aid in distinguishing red and white oaks. In general, the heartwood of the red oaks was presumed to have a distinct reddish tinge, while that of the white oaks was considered to be of varying shades of brown, without a carneous cast. However, even before the redefinition of the two subgenera, and the subsequent shift of eight of the so-called white oaks to the red oak group, as suggested in the first paper of this series, color was recognized as not being wholly satisfactory diagnostically. The shifting of these eight species, if it is accepted by taxonomists, renders color even less acceptable than before in determining subgeneric limits. But with this shift, color has assumed a new significance in isolated cases, serving as a means to distinguish species which are otherwise very similar. For example, *Q. arizonica* Sarg. may be separated from *Q. emoryi* Torr. by the color of the sapwood; it has a distinct reddish cast in the latter and ranges from creamy white to tan or light brown in the former, without a reddish tinge.

Vasicentric Tracheids. The shape, length, type of pitting, and general arrangement of the vasicentric tracheids are similar throughout the genus.

Explanation of figures 1–9

FIG. 1. *Q. velutina* Lam. Note the large ray-crossing pits, restricted to definite pit fields, also the vermiform vasicentric tracheids with large bordered pits. ×430. FIG. 2. *Q. alba* L. Note the thick-walled fibers; also gelatinous fibers scattered over the section, the gelatinous layer appearing darker. ×450. FIG. 3. *Q. velutina* Lam. A mass of vasicentric tracheids sheathing a vessel. ×285. FIG. 4. *Q. alba* L. Narrow, fairly regular bands of zonate parenchyma, characteristic of many white oaks and uncommon among the red oaks. ×240. FIG. 5. *Q. imbricaria* Michx. Wider and less even bands of parenchyma than those in figure 4, more common among the eastern deciduous red oaks than elsewhere. ×240. FIG. 6. *Q. virginiana geminata* Sarg. Note the abundance of the parenchyma and that the zonation is obscured. This type of distribution characterized the live oak group. ×240. FIG. 7. *Q. palustris* Muench. Tangential section showing sparse crystal formation. ×180. FIG. 8. *Q. Prinus* L. Tangential section showing moderately abundant crystal formation. ×180. FIG. 9. *Q. Emoryi* Torr. Tangential section showing excessively abundant crystal formation. ×180.

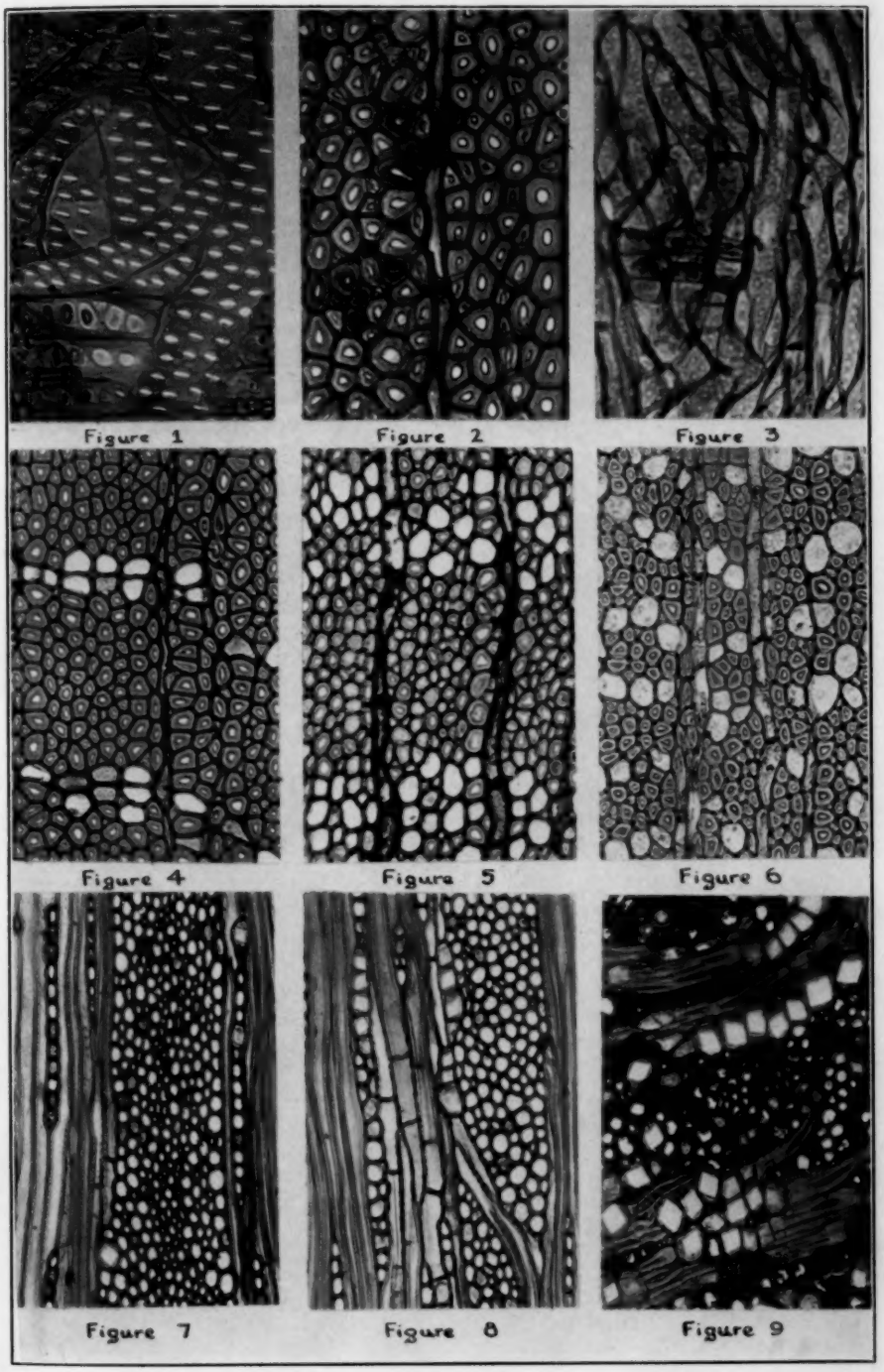

Figure 1 Figure 2 Figure 3

Figure 4 Figure 5 Figure 6

Figure 7 Figure 8 Figure 9

Units of this type are restricted to the immediate vicinity of the vessels, about which they form multiseriate sheaths consisting of vermiform, profusely pitted (bordered, with an oval, included aperture) cells intermingled with strands of longitudinal parenchyma (fig. 3). The length of the tracheids fluctuates within remarkably small limits throughout the genus, averaging between 550 and 700 microns, or approximately one-half of the average fiber length. As is true of other cells, although much less markedly, the tracheids are smaller in the xerophytic and shrubby oaks than elsewhere. Further, the larger the pore, the shorter and more twisted the tracheids associated with it.

In macerated material, vasicentric tracheids are extremely variable in shape. The majority are slightly twisted, with more or less blunt apices; others are forked at one or both ends; some have horizontal end walls; many are swollen at one end and taper into an elongated, thread-like extension at the other end; a few taper evenly at both ends and resemble fibers in outline. The last type can easily be distinguished from fibers by the abundance of pits and the type of pit-sculpture on the walls. Intertracheid pitting and the tracheid-vessel pitting are similar and have already been described in the discussion of the vessels.

Miscellaneous Data. Except as already indicated, weight, thickness of sapwood, etc., which could not be thoroughly substantiated in this research and are hence of unknown value in distinguishing species, will not be considered further.

SUMMARY AND CONCLUSIONS

In addition to the indications of subgeneric limits presented by the correlation existing between leaf-form and the structure of the late-wood pores and the type and distribution of tyloses, several additional indications of the validity of these limits are noted. While none of these permits of an absolute segregation of species comparable to that described on the basis of leaf-form and late-wood pore anatomy, they are of value and may be enumerated as follows:

1. The frequency of longitudinal parenchyma is noticeably higher in *Erythrobalanus* than in *Leucobalanus*. This is especially true of the live oak group in *Erythrobalanus*, in which parenchyma is often so abundant that the

Explanation of figures 10–15

FIG. 10. *Q. imbricaria* Michx. Broad ray type of deciduous red oaks. Pattern formed on tangential surface of wood. ×2.5. FIG. 11. *Q. imbricaria* Michx. Portion of broad ray highly magnified. The shape of the cells of both uniseriale and broad ray is typical for the genus. ×100. FIG. 12. *Q. virginiana* Mill. Pattern formed by broad rays on tangential surface of wood. ×2.5. FIG. 13. *Q. virginiana* Mill. Broad ray highly magnified. Note aggregate ray condition typical of many live oaks. ×100. FIG. 14. *Q. stellata* Wang. Pattern formed by broad rays on tangential surface of wood. ×2.5. FIG. 15. *Q. stellata* Wang. Broad ray highly magnified. ×100.

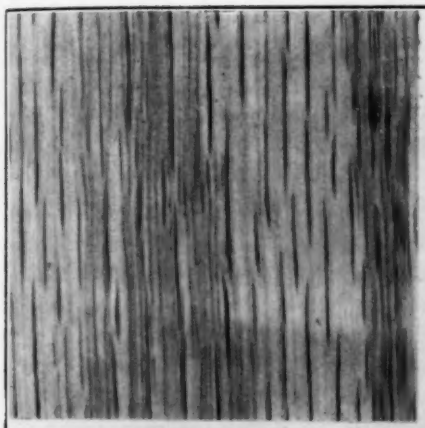

Figure 10

Figure 11

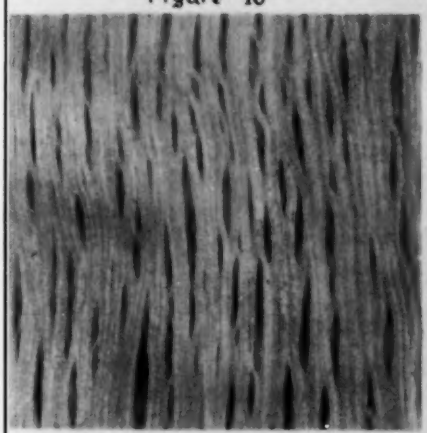

Figure 12

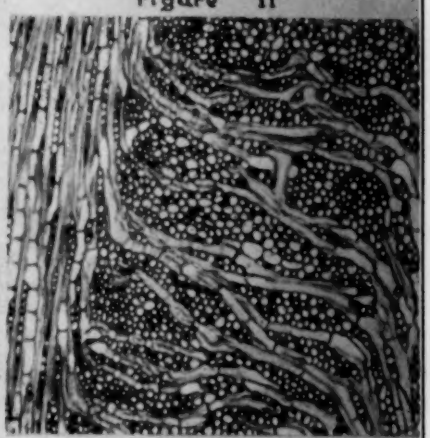

Figure 13

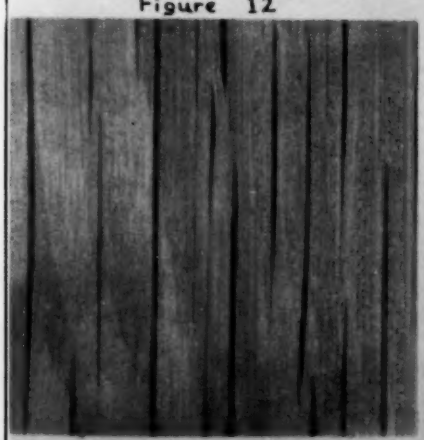

Figure 14

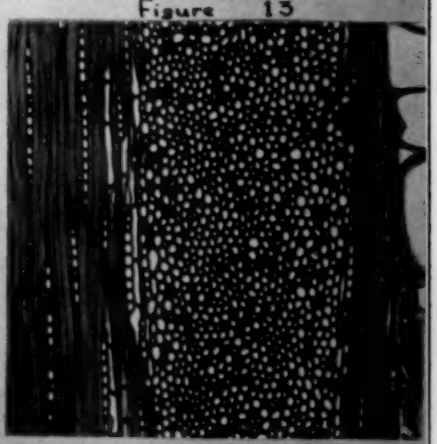

Figure 15

zonate arrangement which typifies the genus *Quercus* is obscured. The shrubby species tend toward a high parenchyma volume, irrespective of the subgenus. The size, shape, type of pitting, etc., of the cells are similar throughout the genus.

2. The broad rays of *Erythrobalanus* are generally shorter and more abundant than those of *Leucobalanus*. The live oaks, in *Erythrobalanus*, are distinct from the deciduous red oaks on the basis of the very short, stubby, extremely broad, excessively abundant rays, many of which are typically aggregate. Among the deciduous red and white oaks, there is considerable overlapping in height and width; however, whereas the average ray height among the red oaks rarely exceeds one-half inch, average ray heights of from three-fourths to one-and-one-half inches are common among the white oaks. In general, dry site stimulates broader rays; dry site plus evergreen habit very broad, but shorter rays with a distinct tendency toward the production of rays of the aggregate type; wet site appears to exert no constant directional influence on width or height.

3. Certain physical distinctions hold between the woods of the red and white oaks. For example, the color of the heartwood may be used with reservation; the white oaks have from tan to dark brown heartwood, devoid of reddish tinge, while the red oaks, in contrast, have heartwood with a roseate cast; there is considerable overlapping in this regard. As regards weight, the literature reveals that the live oaks have the heaviest woods and the deciduous red oaks the lightest. The wood of all of the species studied was odorless and tasteless. No hardness tests were made.

In all other respects, the woods of *Erythrobalanus* and *Leucobalanus* merge insensibly in their structural and dimensional features.

BUREAU OF INDUSTRIAL CHEMISTRY
UNIVERSITY OF TEXAS
AUSTIN, TEXAS

Literature Cited

1. **Abromeit, J.** 1884. Ueber die Anatomie des Eichenholzes. Jahrb. Wiss. Bot. **15**: 209–281.
2. **Bailey, I. W.** 1933. The cambium and its derivative tissues. No. VIII. Structure, distribution, and diagnostic significance of vestured pits in dicotyledons. Jour. Arnold Arb. **14**: 259–273.
3. **Bailey, I. W. & Tupper, W. W.** 1918. Size variation in tracheary cells: I. A comparison between secondary xylems of vascular cryptogams, gymnosperms, and angiosperms. Proc. Am. Acad. **54**: 149–204.
4. **Büsgen, M. & Münch, E.** 1929. The structure and life of forest trees. Transl. by T. Thomson. John Wiley and Sons, N. Y.
5. **Chalk, L.** 1936. Distribution of lengths of fibers and vessel members and the definition of terms of size. Imp. For. Inst., Oxford.
6. ————. 1937. The phylogenetic value of certain anatomical features of dicotyledonous woods. Ann. Bot. N. S. **1**: 409–428.

7. **Chalk, L. & Chattaway, M. M.** 1934. Measuring the length of vessel members. Trop. Woods **40**: 19–26.
8. **DeSmidt, W. J.** 1922. Studies of the distribution and volume of the wood rays in slippery elm (*Ulmus fulva* Michx.). Jour. For. **20**: 352–362.
9. **Ezekial, M.** 1930. Methods of correlation analysis. John Wiley and Sons, N. Y.
10. **MacMillan, W. B.** 1925. A study in comparative lengths of tracheids of red spruce grown under free and suppressed conditions. Jour. For. **23**: 34–42.
11. **Mell, C. D.** 1910. Determination of quality of locality by fiber length of wood. For. Quart. **8**: 419–422.
12. **Myer, J. D.** 1922. Ray volumes of commercial woods of the United States and their significance. Jour. For. **20**: 337–351.
13. ————. 1930. The structure and strength of four North American woods as influenced by range, habitat, and position in the tree. N. Y. Coll. For. Tech. Bull. 31.
14. **Record, S. J.** 1934. The identification of the timbers of temperate North America. John Wiley and Sons, N. Y.
15. **Shephard, H. B. & Bailey, I. W.** 1914. Some observations on the variation in length of coniferous fibers. Proc. Soc. Amer. For. **9**: 522–525.
16. ————. 1915. Sanio's laws for the variation in size of coniferous tracheids. Bot. Gaz. **60**: 66–71.
17. **Sudworth, G. B. & Mell, C. D.** 1911. The identification of the important North American oak woods, based on a study of the anatomy of the secondary wood. U.S.D.A. For. Serv. Bull. 102.
18. **Williams, S.** 1939. Secondary vascular tissue of the oaks indigenous to the United States—I. The importance of secondary xylem in delimiting *Erythrobalanus* and *Leucobalanus*. Bull. Torrey Club **66**: 353–365.
19. ————. 1942. Secondary vascular tissues of the oaks indigenous to the United States—II. Types of tyloses and their distribution in *Erythrobalanus* and *Leucobalanus*. Bull. Torrey Club **68**: 1–10.

BULLETIN OF THE TORREY BOTANICAL CLUB
69(2): 130–133 FEBRUARY, 1942

CULTURE OF ISOLATED ROOTS OF ACACIA MELANOXYLON

JAMES BONNER

INTRODUCTION

The culture of isolated roots of several herbaceous species of plants over extended periods has been previously reported by various authors. The present paper deals with preliminary observations concerning the culture of isolated roots of a tree species, *Acacia melanoxylon*.

METHODS

Seeds were collected in the fall from large trees and were disinfected by a ten minute treatment with 0.1 per cent $HgCl_2$. Boiling water was next poured over the seeds, which were then allowed to soak for 24 hours. Heat treatment of these seeds appeared to be essential to germination. Germination took place on moist sterile filter paper contained in Petri dishes. Root tips approximately 1 cm. long were removed from the seedling roots and transferred to Petri dishes containing 20 cc. of nutrient medium[1] similar to that used in other investigations (1). All of the cultures were maintained in the dark at 25° C.

EXPERIMENTAL RESULTS

In the first experiment, 6 roots were maintained in the basal medium containing supplements of thiamin, pyridoxine (each 0.1 mg. per liter) and nicotinic acid (0.5 mg. per liter). The roots were subcultured at weekly intervals for 20 weeks by removal of 1 cm. tips to fresh medium. During the first week of culture the average growth increment was 12 mm., while during the twentieth week an average of 11 mm. of growth in length took place. That the growth rate remained roughly constant during the 20 weeks is indicated by the average weekly growth increments for successive 5 week periods, which were respectively 9, 9, 8, and 8 mm. per week.

The growth rate of *Acacia* roots as indicated by the above experiment was markedly smaller than that obtained for certain isolated roots of herbaceous plants such as tomato, clover, and alfalfa (1), grown under similar conditions. Various alterations in the nutrient medium did not, however, result in increased growth of *Acacia* roots. These alterations included: use of solid or semi-solid substrata (0.8 and 1.5 per cent agar media) use of 4, 6, or 10 per cent sucrose in place of 2 per cent, addition of yeast extract or whole

[1] This medium contained per liter of redistilled water; 236 mgs. $Ca(NO_3)_2 \cdot 4H_2O$, 36 mgs. $MgSO_4 \cdot 7H_2O$, 81 mgs. KNO_3, 65 mgs. KCl, 20 mgs. KH_2PO_4, 1.5 mgs. ferric tartrate, and 20 gms. sucrose.

dried yeast in various concentrations, and addition of micro-nutrients (i.e., in addition to those already contained in the medium as impurities) including Zn, Cu, Mn, Mo, and B, to the medium. The mean growth per week was likewise not increased by the use of transfer periods of 2, 3, 4, or more weeks rather than the usual weekly period. The growth of isolated *Acacia* roots under the present conditions was however somewhat slower than that of roots grown under similar conditions but attached to seeds (17.5 mm. per week over a 2 week period) or grown as seedlings in Hoagland's solution in the greenhouse (12.5 mm. per week). It would appear that optimal conditions for the culture of isolated *Acacia* roots were not realized.

In a further experiment, the effect of varied supplements was investigated; the results are given in table 1. Roots maintained in medium contain-

TABLE 1

Influence of various substances on the growth of isolated Acacia roots

Supplements to basal medium	Number of roots	Growth in mm. per week					
		week 1	3	5	15	26	35
None	11	5.5	1.8	0.0	0.0	0.0	0.0
B_1 alone	13	5.0	3.2	0.6	0.0	0.0	0.0
Nicotinic acid alone	15	6.0	2.2	1.0	0.0	0.0	0.0
B_6 alone	12	7.3	3.8	0.0	0.0	0.0	0.0
B_1 + nicotinic acid	17	5.4	6.5	6.0	3.1	0.0	0.0
Nicotinic acid + B_6	13	6.0	4.6	1.6	0.7	0.0	0.0
B_1 + B_6	12	5.9	3.9	1.7	1.4	0.0	0.0
B_1 + nicotinic acid + B_6	17	10.6	8.9	8.9	8.2	6.6	10.0

ing no supplement, or in medium containing only one of the three supplementary substances, grew less in each successive transfer and ceased or nearly ceased growing within 5 weeks. The same was true of roots grown in medium containing supplements of nicotinic acid and pyridoxine or thiamin and pyridoxine. Roots which received thiamin, nicotinic acid, and pyridoxine continued to grow for 35 weeks (averaging 8 ± 0.3 mm. per week) at which time they were discarded. Roots which received only thiamin and nicotinic acid grew somewhat more per week and continued growing for more weeks than roots on other deficient media, but ultimately lagged behind roots receiving all three growth factors. This experiment suggests then that thiamin, nicotinic acid, and pyridoxine all exert positive effects on the growth of isolated *Acacia* roots.

The roots grown in the above experiments were distinguished by their lack of branches and by their lack of secondary thickening. It was not found possible to induce the formation of branch roots. The bases of roots (after removal of the tip) were maintained in nutrient solution for from 1 to 4 weeks without the appearance of branches. In one experiment, 6 roots were

transferred intact (without subculturing) to fresh medium at weekly intervals for 16 weeks. At the end of this period the roots had attained an average total length of 81 mm., although the weekly growth increment had decreased to 0.9 mm. No branches appeared and the roots did not exhibit any marked secondary thickening.

OTHER SPECIES

Unsuccessful attempts were made to cultivate roots from other species of woody plants. In every case liquid as well as solid media were used, and various supplements and sucrose concentrations were tried as with *Acacia*. In three species (grape, lemon, grapefruit) the roots failed to grow at all after excision, a state of affairs which has been met with in some herbaceous plants, notably certain of the *Cucurbitaceae*. In 5 species (*Poinciana gilesii*, orange, *Simmondsia californica*, *Thuja orientalis*, *Parthenium argentatum*), the roots regularly grew for one or more weeks after excision, but ceased growing within three weeks. The average growth in the first week of culture varied from 7 mm. (*Simmondsia*) to 22 mm. (*Poinciana*). In three species a few roots were cultivated through several transfers. Thus, with *Sterculia diversifolia* growth averaged 9 mm. in the first week. Eighty of eighty-two roots did not grow after the fourth transfer. One individual root however was maintained through 21 weekly transfers (in liquid medium supplemented with thiamin, nicotinic acid, and pyridoxine) at an average growth rate of 8 mm. per week, and a second root was maintained through 13 weekly transfers at an average growth rate of 8 mm. per week. Such exceptional roots were also found in the cases of *Bauhinia purpurea* and *Wisteria sinensis* (see also Robbins and Maneval, 2). In all cases, however, the growth rates were low and similar to that of isolated *Acacia* roots rather than to those characteristic of the herbaceous roots previously studied.

SUMMARY

1. Isolated roots of *Acacia melanoxylon* were cultivated for periods up to 35 weeks, in liquid medium containing inorganic salts, 2 per cent sucrose, and supplements of thiamin, pyridoxine, and nicotinic acid. All of these supplements appeared to be essential to the continued growth of isolated *Acacia* roots although the absence of pyridoxine was manifested less strikingly than absence of thiamin or nicotinic acid.

2. The growth rate of isolated *Acacia* roots averaged 8 ± 0.3 mm. per week over a period of 35 weeks. This growth rate, which was about two-thirds that of roots of seedling plants, was in marked contrast to the 40 to 150 or more mm. per week typical of isolated roots of herbaceous species as tomato, alfalfa and clover.

3. No formation of branch roots or extensive secondary thickening was observed in isolated *Acacia* roots.

4. Continued growth in vitro could not be obtained with isolated roots of 12 other species of woody plants with the exception of rare individual roots of *Sterculia diversifolia*, *Bauhinia purpurea* and *Wisteria sinensis*.

California Institute of Technology
Pasadena, California

Literature Cited

1. **Bonner, James.** On the growth factor requirements of isolated roots. Am. Jour. Bot. **27**: 692–701. 1940.
2. **Robbins, W. J. & Maneval, W.** Further experiments on growth of excised root tips under sterile conditions. Bot. Gaz. **76**: 274–287. 1923.

BULLETIN OF THE TORREY BOTANICAL CLUB
69(2): 134–136 FEBRUARY, 1942

CYTOGEOGRAPHY OF OXYDENDRUM ARBOREUM[1]

J. T. BALDWIN, JR.

Oxydendrum DC. is an ericaceous monotype: *O. arboreum* (L.) DC. Though usually a small tree, it may attain a height of more than seventy feet and a trunk diameter of twenty inches (Hough 1924). The leaves and stem are somewhat acidulous to the taste—thus the common names, sorrel-tree and sourwood.

The tree, as shown on the map (fig. 1), is distributed east of the Mississippi River from New Jersey to Illinois and southward to the Gulf of Mexico and northern Florida. The map is based on specimens examined cytologically (*diamonds*) and on those in certain herbaria (*circles*).[2]

TABLE 1

Stations at which O. arboreum was found to have 24 chromosomes at leaf metaphase

West Virginia
- Monongalia County: Morgantown
- Nicholas County: Powell's Mountain
- Raleigh County: Beckley

Virginia
- Bedford County: Coleman's Falls
- Buckingham County: Dillwyn
- Campbell County: Rustburg
- Charlotte County: Keysville
- James City County: Williamsburg
- Pulaski County: Dublin
- Washington County: Abingdon
- Wise County: Coeburn

North Carolina
- Cherokee County: Murphy
- Jackson County: Dillsboro
- Madison County: Hot Springs
- McDowell County: Lake Tahoma

South Carolina
- Greenville County: Marietta
- Oconee County: Upper Whitewater Falls

Georgia
- De Kalb County: Emory University
- Rabun County: Pine Mountain

Alabama
- Bibb County: Pratt's Ferry Bridge
- Clarke County: Jackson
- Cullman County: Cullman
- Morgan County
- Tuscaloosa County: Tuscaloosa
- Wilcox County: Pine Hill

Mississippi
- Jackson County: Ocean Springs

Tennessee
- Polk County: Ducktown
- Putnam County: Baxter
- Sevier County: Elkmont

Kentucky
- Harlan County: Cumberland
- McCreary County: Whitley City

During the summers of 1940 and 1941, as part of a broad program for cytogeographic analysis of North American plants (see Baldwin 1942), the writer, in routine fashion, made chromosome counts for thirty-one collections

[1] Papers from the Department of Botany of the University of Michigan, No. 795. Supported by Faculty Research Fund, Projects No. 540 and 569.

[2] Gray Herbarium, United States National Herbarium, and herbaria of the Field Museum of Natural History, New York Botanical Garden, Missouri Botanical Garden, Cornell University, West Virginia University, Duke University, University of Michigan, University of Tennessee, and University of Georgia. The writer appreciated the privilege of access to these specimens.

of *O. arboreum* from representative stations in the specific range. He also examined cytologically trees growing at The Blandy Experimental Farm in Virginia. The tree, being quite distinctly different from other Ericaceae, is easily recognized from a rapidly moving automobile, so the finding of mate-

FIG. 1. Distribution of *O. arboreum* based upon herbarium specimens (circles) and upon specimens cytologically analyzed (diamonds). FIGS. 2–3. Mitotic metaphase in leaf cell: $2n = 24$. Meiotic metaphase in pollen mother cell: $n = 12$. *ca.* × 650.

rial is easy. Young leaves are produced from spring to fall, and from them leaf smears are readily made. Flowers in many developmental stages are present in a single inflorescence, and good aceto-carmine smears of anthers

are made without difficulty. Moreover, the writer had found intraspecific chromosome-number races in certain other species characteristic of the Appalachian system,—e.g., *Galax aphylla* L. and *Sedum ternatum* Michx.,—and considers that many cases of such polyploidy will be discovered by intensive cytogeographic surveys of species.

However, the chromosome number of *O. arboreum* was not observed to vary. At mitotic metaphase in leaves the $2n$-number is 24 (fig. 2); at meiotic metaphase in anthers the n-number is 12 (fig. 3). The chromosomes are uniformly small and of a similar morphology. Stations for wild plants investigated cytologically are listed in table 1 and, of course, designated on the map.

The conclusion to be drawn from this study is obvious: According to the data at hand *O. arboreum* has throughout its geographic range a $2n$-number of 24 chromosomes.

Department of Botany, University of Michigan
Ann Arbor, Michigan

Literature Cited

Baldwin, J. T., Jr. 1942. Polyploidy in *Sedum ternatum* Michx. II. Cytogeography. Am. Jour. Bot. (in Press).

Hough, R. B. 1924. Handbook of Trees of the Northern States and Canada. Romeyn B. Hough Co., Lowville, New York.

BULLETIN OF THE TORREY BOTANICAL CLUB
69(2): 137–150 FEBRUARY, 1942

THE GENUS DELPHINIUM IN NORTH AMERICA: SERIES ECHINATAE OF SUBSECTION SUBSCAPOSA, AND MISCELLANEOUS NOTEWORTHY SPECIES

JOSEPH EWAN

The present small series of larkspurs is marked phylogenetically as a series in probable advanced position among the North American species. It is characterized at once by its distinctive echinate seed coats and by its well-defined Californian distribution along the eastern rim of the Great Valley. The single species with its three component subspecies making up this series inhabits the warm interior foothills of the Sierra Nevada of California, a region otherwise noted as one of remarkable floristic content. *Delphinium hanseni* lives in the same region with such distinctive endemics as the genus *Carpenteria*, *Collomia rawsoniana*, *Arctostaphylos myrtifolia*, *Githopsis pulchella*, *Wyethia elata* and *W. reticulata*, and the remarkable and unique species *Delphinium purpusi*.

The origin of this well-marked series Echinatae of the subsection *Subscaposa* cannot be determined with any certainty at this time. Though the echinate seeds of *Delphinium hanseni* are unique among the Californian larkspurs, the other characters of flower, follicle, and habit are not at variance with the Californian members of this large subsection. *Delphinium hanseni* may have had its origin conceivably from *D. hesperium*, its closest ally among the related series. Furthermore, what I believe are natural hybrids are fairly frequent between these two species. Cytogenetic studies may yet demonstrate the basis for such suspected hybridism.

The author is again indebted to many curators for continued assistance in various ways. The material to be found in the herbaria enumerated in an earlier paper (1936) has been used as the basis for the present paper. In addition large series from the Academy of Natural Sciences, Philadelphia, the Rocky Mountain Herbarium, Laramie, and the growing collections being assembled by the author through field work and the generous courtesy of several correspondents, have been studied. In particular valuable material has been received from Mr. Milo Baker, Dr. Lincoln Constance, Dr. C. L. Hitchcock, Dr. R. F. Hoover, Mr. John Thomas Howell, and Mr. J. W. Thompson. A visit to the Herbarium Greeneanum at Notre Dame University during February, 1940, was particularly profitable. The *Delphinium* collection there has more critical sheets than any other North American herbarium examined, notwithstanding its relatively small size. Several species of great rarity in the largest collections are represented among E. L. Greene's collections. I am indebted to Dr. Theodor Just for his courtesies. The Parry Her-

barium at Iowa State College, Ames, under the curatorship of Dr. George Goodman, is rich in historic collections. The sheets must often be given individual study against Parry's scattered published annotations and floristic lists, however, for they commonly are very imperfectly labelled.

HISTORICAL NOTE

Though Thomas Bridges, William Lobb and J. M. Bigelow traversed the Sierra foothills inhabited by *Delphinium hanseni* during the meridian decades of the nineteenth century, I have not seen any specimens of this larkspur taken by them. Indeed this *Delphinium* seems not to have been taken until the final decades of the last century when Greene, Curran (Mrs. Mary Katherine Layne Curran Brandegee at her death), Congdon, Hansen, Jepson, and Davy penetrated these foothill valleys and Digger Pine (*Pinus sabiniana*) slopes. Greene first distinguished the plant as a variety of *Delphinium hesperium*. At this time (1891) Greene had not seen fruiting specimens, but he was quick to propose (1896) the variety for species status when he saw the "marked peculiarity of the seeds" demonstrated by fruiting specimens obtained by Alice Eastwood. At this time (1896) he described in a rather indefinite manner "the variety or subspecies" *arcuatum* without assigning a representative collection or so much as delimiting it with a blanket distributional phrase.

One of the most prophetic statements regarding *Delphinium hanseni* was that of Dr. Anstruther Davidson when he wagered that though Asa Gray in the Synoptical Flora (**1**: 49. 1895) had placed the hispid-hirsute-leaved larkspurs of central California under *D. hesperium* he felt all the hispid forms would prove to be *D. hanseni* when the seeds were examined and the species better known. In my present study this wager of Dr. Davidson's (1908) has been borne out and, apart from individuals of *D. variegatum* which occur infrequently in the range of *D. hanseni*, no other hispid-hirsute-leaved larkspur occupies the central Californian Sierra foothills. This is a fact of value in the identification of imperfect specimens from this region.

It is appropriate historically that a *Delphinium* so distinctive of lower-middle elevations of the Sierra foothills should bear the name of a collector, George Hansen (1863–1908) who so eagerly botanized over this region. Jepson has written of Hansen in the Dictionary of American Biography and also, with portrait, in Madroño (**1**: 183–185. 1928).

CONTINUED USE OF THE CATEGORY SUBSPECIES

Since formulating my views on the desirability of using the subspecies category (1936, p. 329) I have continued to scrutinize the practice. I remain confident of the enduring value of the use of the term subspecies to replace the more inexact and variously used term variety. It is unfortunate that

several authors see fit to recast the names given by workers using the subspecies category into new combinations under "variety." Nor do I see any substantial progress in the reciprocal practice of somewhat automatically changing varietal names to subspecies as new combinations. To obviate this persistent confusion, which cannot but reflect discredit upon systematic botany, it seems to me desirable to adopt the straight trinomial when referring to the rank below that of species, in the manner established many years ago by Coville, Piper and Abrams. Thus whether a given name was proposed as a subspecies or variety becomes inconsequential beside the direct practical manner of referring, for example, to *Delphinium hanseni arcuatum*.

Along with this usage may stand another device to remove nomenclatural difficulty today. Authors have treated the populations of the nomenclatorial type of a species as subspecies or variety *typicum*. Again some authors have used for the good reason of avoiding the concept of "biologic type" the terms *originarium*, *genuinum*, or *verum*, indicating that it is the subdivision which includes the type of the specific epithet. There has been some use of the specific epithet unaltered (e.g., *Stachys recta* subsp. *recta*) among European systematists but apparently no use of this clear and direct device has been made by taxonomists in this country.

Benson has pointed out to good effect (Bull. Torrey Club **68**: 160. 1941) that "while the validity of the philosophy behind the use of the formal name 'var. *typicum*' is admitted, it is [his opinion] that publication of formal trinomials for typical varieties is unnecessary." In the present proposal there need be no formal publication of typical varieties but the convenience of using the repetitious trinomial for precision of reference to the typical subspecies is accomplished. In this and future papers I shall follow this practice, found workable by the systematic zoologists, and embraced in Article 56, Recommendation XXXV, International Rules of Botanical Nomenclature (Jour. Bot. suppl. 1934).

SYSTEMATIC TREATMENT

Subsection *Subscaposa* (Huth) Ewan, Bull. Torrey Club **63**: 330. 1936.

Series **Echinatae** ser. nov. Semina obpyramidalis et acutis, perspicue integumentis echinatus cum imbricati-squamellatis.

Perennials of subcapose habit with seeds distinctly scaly-echinate and bur-like with loosely imbricated prominent thin scales or processes on the seed face. TYPE SPECIES of series Echinatae: *D. hanseni* (Greene) Greene.

KEY TO THE SUBSPECIES OF DELPHINIUM HANSENI

Stems short (30 cm. tall or less), stout; leaves shaggy-white pilose; raceme dense ..... 1c. *D. hanseni kernense*

Stems taller (40–90 cm. tall), often strict but scarcely stout; leaves glabrate to hirsute or pubescent along veins but not pilose; raceme dense to loosely interrupted.

Flowers dark blue to purple, the racemes often dense or compact, frequently narrow or spiciform; lower leaves generally withering at flowering time ..... 1a. *D. hanseni hanseni*

Flowers whitish or pink, seldom blue, the racemes commonly loose or interrupted, not at all spike-like; lower leaves often green and conspicuous at flowering time ..... 1b. *D. hanseni arcuatum*

1a. D. HANSENI (Greene) Greene,[1] Pittonia **3**: 94. 1896, based on *D. hesperium* var. *Hanseni* Greene, Fl. Franciscana 304. 1892, in turn based on *Geo. Hansen* coll., 1891, from Amador Co., Calif., without definite locality. TYPE (Notre Dame Herb. without accession number) studied. Another sheet (N. D. Herb. 3413), Eldorado, Calaveras Co., VI 1889, *Greene*, is a good paratype; though not referred to by Greene, unmistakably involved in Greene's original description. Jepson records (Fl. Calif. **1**: 523. 1915) a verbal statement made in 1896 by Prof. Greene to the effect that "the best type of it is Davy's 1326, Calaveras Co." Greene here likely had in mind the ideal type representative of the population in nature as he knew it.

Slender virgate perennial 50–90 cm. tall, arising from a rather short slender taproot, the stems greenish or fuscous above and darkening below, rather uniformly puberulent throughout with longitudinal glabrous lines, sometimes pilose at the base with white hairs; leaves not very conspicuous and withering at flowering time, mostly basal, dimorphic, the lower rhomboid with an ample little-divided blade, hirsute, 4–9 cm. wide, the upper divided to midrib into 3 or 5 narrow primary segments, the blade about $\frac{1}{2}$ as broad as that of the lower leaves, much less pubescent or even glabrate, the petioles long, even the uppermost more than twice as long as the blade, all usually pilose or the upper merely puberulent; raceme rather compact, narrow-spiciform, elongating relatively little in fruit, the flowers numerous, commonly dark blue-purple or again (especially among colonies on the margins of its range) pinkish or even white and fading pink, short-pedicellate, the pedicels slender, ascending, shorter than the spur; sepals oblong, bluntish or rounded, commonly hoary with a median band of pubescence, 6–8 mm. long, spur curving, 7–10 mm. long, slender, acutish; follicles erect, nearly oblong, 10–14 mm. long, with slender moderately divergent filiform cusps, puberulent, a little venulose, borne on strictly ascending pedicels commonly appressed to rachis; seeds obpyramidal with a flat summit, silvery white, echinate, the faces with imbricate scale-like processes.

Often large colonies of 20–200 individuals in adobe or loamy soils of open hillsides, oak clearings or margins of cultivated fields in the Blue Oak-Digger Pine association, at 1500–3660 feet, but infrequent above 2500 feet. Sierra Nevada foothills from Butte Co. south to Madera Co., California, where plants somewhat intermediate between this and subspecies arcuatum occur. It spreads out upon the floor of the Great Valley on alkaline plains in Merced Co. April–May.

Representative material: CALIFORNIA—BUTTE: Bidwell Park, *Heller*

[1] It is the author's express intent to avoid *formal* establishment of any name for *typical* subspecies, i. e. "*D. hanseni hanseni* nomen nov.," but to indicate by such usage that the typical phase of the species is intended. Technically such trinomials should be credited to Greene; the trinomial is wholly unnecessary except when the component subspecies of the species is in question. The aim is to give a definite name of reference without involving nomenclature.

13625; Chico, *Ed. Palmer 2076;* Butte Co. foothills, 1897, *Bruce.* SUTTER: Marysville Buttes, *Heller 1914.* NEVADA: Limekiln Reh. near Wolf Creek, *Eastwood 3441.* PLACER: Auburn, VI 1886, *Shockley;* Roseville, *Congdon.* AMADOR: Ione to Clement, 2000 ft., *Belshaw 805;* Agricultural sta., 2000 ft., VI 1893, *Hansen 104;* Irishtown, 1500 ft., 18 VI 1896, *Hansen 104* (Pomona Coll.—note same coll. no.). CALAVERAS: Copperopolis, *Tracy 5576;* Table Hills near Sheep Reh., *Davy 1608;* Milton, *Davy 1321;* Wallace, 1914, *McMurphy;* Mokelumne Hill, *Blaisdell.* TUOLUMNE: 5 mi. e. LaGrange, *Hoover 2144* (fresh fls. white); Hetch-Hetchy, 3660 ft., *A. L. Grant 1267* (Jepson Herb.). STANISLAUS: Knights Ferry, *Hoover 1031;* LaGrange, *Hoover 959* (fls. light pink). MERCED: 5 mi. s. Merced, *Hoover 555* (fls. white or drying pale blue); 10 mi. s. Merced, *Hoover 556* (fls. dark purple, cf. his 555); 3 mi. ne. Merced Falls, *Belshaw 2027* (fls. pale blue, seeds lightly echinate). MADERA: Daulton Creek, n. Madera, *Hoover 904;* Madera, *Eastwood 12609.*

George Hansen wrote Prof. Greene that he had "never found [*D. Hanseni*] below 1500 feet [elevation] nor above 1800 feet" (mss. note in Greene Herb.). We now know its altitudinal limits to be from 1500 to 3660 feet, though it is most characteristic of the lower elevations. Helpful notes on Hansen's little-known collecting localities may be found in Jepson's biography in Madroño (**1**: 184). The range of *D. hanseni hanseni* and of *D. hanseni arcuatum* are mutually exclusive except for Madera County, the zone of overlap of these two subspecies. Here some individuals are difficult to refer to one subspecies or the other with certainty. A single collection, Lindsey, Tulare Co., 1925, *Harter* (Calif. Acad.), has been seen which falls geographically far beyond the general range of typical *D. hanseni.* This collection has the dark blue-purple flowers and is in every way typical of the more northern plants.

There is a small-flowered race (sepals 5–7 mm. long, paler blue, the spur straight) in Amador and Calaveras counties which deserves some study. In fact most of Hansen's collections represent this race. Along the margins of the Great Valley Dr. Hoover has detected some interesting individuals. One collection seems clearly to be a hybrid between *D. variegatum* and *D. hanseni,* the former species occurring in the same colony (*Hoover 956* and *956a,* LaGrange, Stanislaus Co., 13 IV 1936). On May 2nd, of the same year, some plants of the colony exhibited seeds like *D. hanseni* but the processes were more or less scattered and not closely studding the seed coat. Some plants otherwise identical had bullet-shaped seeds with a "loose cellular dirty-white coat without projections," suggestive of *D. variegatum.*

1b. D. HANSENI var. ARCUATUM Greene, Pittonia **3**: 94. 1896, based on undesignated type. LECTOTYPE: Yosemite Valley, VII 1896, *Jepson sine numero* in Jepson Herb. Paratype: Little Yosemite, VII 1875, *McLean* in Univ. Calif. Herb. No sheets in the Greene Herb. at Notre Dame Univ. offer a type basis.

Slender erect or straggling perennial 40–80 cm. tall of varying habit,

arising from a rather long, woody, sometimes stout, much-branched taproot, the stems greenish, bluish or violescent, not strictly virgate, sometimes laxly spreading, puberulent or glaucescent above, pubescent toward the base; leaves green and evident at flowering time, almost altogether basal, not distinctly dimorphic since the cauline commonly much reduced, inconspicuous or wanting, the lower irregularly pentagonal or rhomboidal, the blade ample, 4–6 cm. across, with 3 to 5 unequal broad primary divisions, the ultimate divisions few, variable, blunt to acute, glabrate except for the long spreading hairs along the veins and on the margins (or when the blade is only 2–3 cm. wide then hairy-pubescent on both surfaces and the segments involute), the petioles always white-pilose or ciliate; racemes loose, elongating in fruit, the flowers few, commonly greenish-white tinted with green or red umbo, often variable in the same colony, the pedicel about equaling the spur; sepals oval or nearly oblong, obtuse or barely acute, puberulent but without a median band of pubescence, often umbonate, (7 to) 9–10 mm. long, the spur often curving upwards, rather stout, 7–10 mm. long; immature follicles indicate the same characters as *D. hanseni hanseni*, the fruiting racemes 15–20 cm. long; ripe seeds unknown.

Small colonies in thin rocky or sandy soils among boulders and shrubs, commonly in the shade, sometimes about waterfalls and springy seeps at higher elevations, generally in Blue Oak-California Buckeye association, less often with *Libocedrus* along the streams, from 1500–4000 feet. May.

Representative material: CALIFORNIA—MARIPOSA: foot of Yosemite Falls, *Chandler 1144;* Mariposa, 1883, *Congdon.* MADERA: Raymond, *Eastwood 12528;* Fresno Creek, *Hall 10044.* FRESNO: Dunlap, *Jepson 2758;* 1 mi. nw. Squaw Valley, 1600 ft., *Constance 2226.* TULARE: Porterville, 1900, *Dudley;* Tule R., 1897, *Dudley;* Pine Flat near Calif. Hot Sprs., *Moxley 579;* Lemon Cove, *Bacigalupi 1189;* Springville, *Purpus 5049;* Kaweah R. Basin, *Hopping 22.* KERN: Erskine Creek, *Purpus 5016* (USNH); Kern R. Canyon, *Peirson 7316, Abrams 11987;* Caliente Creek Canyon, *Keck 2264.*

Delphinium hanseni arcuatum shows considerable variability in its characters, even within the same colony. It represents quite uniformly the pale-flowered phase of this species. One collection, *Bacigalupi 2344* (Ewan Herb.), from 5 mi. s. Fairview, Lower Kern R. Canyon, 3200 ft., Tulare Co., is remarkable for the bright blue flowers in an elongated sparsely flowered raceme. The leaves are typical of *D. hanseni arcuatum* but the fact that *D. purpusii* grows in the same region (*Bacigalupi 2342*, Lower Kern R. Canyon, 3520 ft.) suggests the possibility of hybridization with that species. The flower color of *Bacigalupi 2344* is unlike that seen among any of several score collections of *D. hanseni.*

Some collections are intermediate between the two subspecies *D. hanseni hanseni* and *D. hanseni arcuatum.* These plants which combine characters are numerically few among the total series studied and come from both extremities of the range of *arcuatum.* These intermediates may be illustrated by three combinations: *a.* dark blue and whitish flowers in same colony, as Mariposa, 1895, *Congdon* (Dudley Herb.) and Kings R., Fresno Co., 1923,

Duncan (Dudley Herb.); *b.* subsp. *Hanseni* as to flower color and inflorescence but subsp. *arcuatum* in leaf characters, as Greenhorn Range, Kern Co., *Hall & Babcock 5065* (Univ. Calif. Herb.). This collection was placed in *D. hanseni kernense* with some question by Davidson; *c.* variation in shape of follicle within same collection: Raymond, Madera Co., *Eastwood 12528* (Pomona Coll.).

1c. D. HANSENI var. KERNENSE Davidson, Muhl. **4**: 37. 1908, based on *Hasse & Davidson 1703* from "dry sunny slope," Mt. Cummings, Tehachapi Range, Kern Co., Calif. TYPE (Los Angeles Mus. Herb. 3976) studied.

Stout, strict, simple-stemmed perennial 20–35 cm. tall, arising from a cluster of deep, stout, woody roots, the stem cyaneous, puberulent above, pubescent toward the base with short curling hairs; leaves chiefly basal, suborbicular or broadly deltoid, the ultimate segments bluntish or shortly acute, mucronate, shaggy-white pilose, especially along the veins beneath, thinly pilose above, 3.0–3.5 cm. long, 4.5–5.5 cm. broad, the petioles noticeably long, 3–4 or even 10 cm. long, pilose; raceme rather dense, short, 5–8 cm. long, the flowers pale bluish white, sepals ovate, 7–10 mm. long, recurved at tips, uniformly puberulent externally, about equaling the lower petals, the blade of petals rounded, scarcely emarginate, the spur short, 6–9 mm. long; follicles unknown.

Small colonies on grassy slopes among scattered shrubs of *Ceanothus* or *Arctostaphylos*, just below the thin forest of Yellow Pine. Dr. Davidson reports that Mt. Cummings was reached from the east, camping near "Dr. Minne's Mine" about seven miles west of Tehachapi station (see Muhl. **4**: 65–68. 1908). Bauer does not record this *Delphinium* for the Tehachapi Range (Bull. S. Calif. Acad. Sci. **29**: 96–99. 1930).

Other collections examined: CALIFORNIA—KERN: Caliente Creek, *F. Grinnell 12* (USNH); Bisses sta., *Dudley 469* (USNH, Dudley Herb.); near Bena, Tehachapi, 1000 ft., IV 1928, *H. L. Bauer* (Univ. S. Calif.).

When characterizing *D. amabile pallidum* I then (1936, 337) placed *D. hanseni kernense* there as a doubtful synonym of that subspecies of the Mt. Pinos region to the southwest of the Tehachapi Range. At that time I had seen but one other collection aside from Davidson's type. Moreover, the type collection of *kernense* is singular in some respects; of course it is an early season collection. Though the seeds are still unknown to me I am restoring this subspecies to its original alliance with *D. hanseni*. All of the collections cited by me under *D. amabile pallidum* are properly that species. Though these local Kern County delphiniums agree in having a stout strict habit, nearly the same pallid flower color, and flower size, they may be distinguished as follows:

Raceme densely flowered; flowers bluish white; lower petals scarcely emarginate; leaves shaggy-white pilose ..... *D. hanseni kernense*
Raceme rather open to densely flowered; flowers whitish; lower petals distinctly emarginate; leaves generally glabrous ..... *D. amabile pallidum*

MISCELLANEA OF VARIOUS NOTEWORTHY DELPHINIUMS

For purposes of citation in current floristic surveys and manuals it is desirable to append here the following notes relative to species belonging to other series or subsections of the genus:

1. **D. bakeri** Ewan, sp. nov., based on *Milo S. Baker 9489* from Coleman Valley, Sonoma Co., Calif., V 1939. TYPE (Ewan Herb. at Univ. Colo.) and isotype in M. S. Baker Herbarium, Santa Rosa Junior College, Calif.

Slender comely perennial 50–65 cm. tall, arising from a cluster of thickened tuberiform fleshy roots, the stems erect, rather fistulous, dark reddish below, subglabrous with thinly scattered hairs, leafy throughout, the leaves decorative, not withering at flowering time, ample, rather thin, the blades of the principal leaves Ranunculus-like, 6.5–7.5 cm. wide, shallowly pentafid, the primary segments of broadly cuneate lobes, these again crenately toothed into short-apiculate or mucronulate teeth, the upper cauline leaves reduced and more deeply 5- or 3-divided, all glabrous or nearly so, a little paler beneath, the petioles slender, subamplexicaul by a flaring base, the base fuscous-hirsute with spreading golden (? glandular) hairs; racemes short-oblong, rather loosely few-flowered (5–15), the flowers on ascending or spreading pedicels 8–20 mm. long at anthesis, their sepals dark blue or purplish but bright, lance-ovate, acute, 11–13 mm. long, glabrous, a little shorter than the slender nearly straight spur, the upper petals, oblique, somewhat crisped, white, the lower petals erosulate or irregularly notched, the blade oblong, blue-purple, inconspicuously villous with a few whitish hairs; immature follicles slender, suberect, glabrous, venulose, with rather prominent cusps; seeds unknown.

Herba perennis caulibus erectis gracilibus, 50–65 cm. altis, e radice grumosa tuberiforma, simplicibus, interdum fistulosis, furvis, subglabris; foliis consimilis Ranunculo, exmarcidis, amplis, interdum tenuis, 6.5–7.5 cm. latis, pentapartitibus, segmentis lato-cuneatis divisis crenatis et breve apiculatis vel mucronulatis, caulibus superioribus reductis, profunde pentapartitibus vel tripartitibus, omnino glabris vel prope, pallidis subter, petiolis gracilibus subamplexicaulibus lucidis hirsutisque atque (?) glandulosis; racemis suboblongis, floribus 5–15, inferioribus remotis, pedicellis divaricatis vel ascendentibus 8–20 mm. longis, sepalis atrocaeruleis tamen lucidis lanceo-ovalibus acutis, 11–13 mm. longis, glabris, calcar subrectis gracilibusque longioris quam sepalis, petalis superioribus obliquis, crispulatis, candidis, inferioribus oblongis, erosulatis, atrocaeruleis, vix villosulis; folliculis immaturis suberectis et gracilibus glabrisque venulosis, cuspide prominentiore ornatis; seminibus ignotis.

Delphinium bakeri is a remarkable species. Mr. Milo S. Baker writes (3 IV 1940) that he has known of its existence for eight to ten years but has never seen it elsewhere. The species grows today along fence rows and in heavy low brush but was formerly much more abundant than now at Coleman Valley, growing where there are now grainfields. The ranch where it grows "has been used as a dairy ranch all these years. It is now nearly extinct on this ranch at least. I thought," says Mr. Baker, "it rather closer to *D. trollifolium* than to any other local species. However it does not seem to be poisonous to stock as is that species." Coleman Valley, west of Occidental, at an

elevation of from 400 to 500 feet, has a colony of *Ranunculus orthorhynchus,* which, according to Milo Baker, is otherwise not known from Sonoma County but does occur in Lake County at 2300 feet. Also growing with this larkspur is *Potentilla elata,* as Mr. Baker says, "where one would expect *P. californica.*" Again, *Potentilla elata* occurs near *Ranunculus orthorhynchus* in Lake County. Keck, under Horkelia, records (Lloydia **1**: 84. 1938) three collections of this *Potentilla* for Sonoma County. The distribution of these three species belonging to two plant families suggests that they are relicts in the present flora of California's North Coast Ranges. It will be particularly interesting to discover *Delphinium bakeri* in Lake County! Prints of the unique type collection will be distributed to several herbaria and to other interested persons in the hope that this fast disappearing larkspur may be saved from extinction.

2. **D. caprorum** Ewan, sp. nov., based on *J. W. Thompson 15206* from Goat Rocks, 7000 ft., Cascade Mts., Wash. TYPE (Ewan Herb. at Univ. Colo.), isotypes to be distributed.

Showy stout low subsucculent perennial 15–20 cm. tall, arising from a slender basal stem upon a cluster of cord-like deep-seated roots; stem simple, glabrous, cyaneous or pale; leaves predominantly basal, orbicular in outline, 2.5–5.5 cm. wide, tripartite, the lateral primary segments again ternate, the ultimate segments oblong, approximate or close-set or even oval and overlapping, all obtuse, mucronulate, the veins prominent, the lower leaves on spreading petioles 10–12 cm. long; racemes showy, oblong, rather loosely 7–15 flowered, tardily elongating below; flowers on ascending pedicels, lightly villous distally, large, 15–24 mm. long, their sepals oval to ovate, obtuse or barely acute, dark blue or purplish, rather dull externally, finely dark venose, 14–17 mm. long, 7–11 (or 13!) mm. wide, glabrous or with a light band of puberulence medianly, the spur about equaling sepals, proportionately slender, curving at the tip, acute, the upper petals clavate-oblong, white, darkly venulose, the lower petals erosulate and shallowly retuse, the blades suborbicular, dark blue-purple, with a central floc of white curling hairs; follicles oblong, nearly parallel, only a little spreading, 11–14 mm. long, hirsutulose dorsally, rather faintly venulose; seeds oblong or bullet-shaped 2 mm. long, jet-black with a narrow white wing on the weak angles.

Herba humilis speciosis perennis caulibus rigidis subsucculentis 15–20 cm. altis, e radice valido funiforma, simplicibus, caesiis glabrisque; foliis imprimis ad caulis basim confertis, orbicularis, 2.5–5.5 cm. latis, tripartitibus, segmentis lateralis contra ternatis, divisis oblongis vel approximatis etiam ovalis valvatisque, omnino obtusis, mucronulatis, venosis, foliis inferioribus petiolatis 10–12 cm. longis; racemis speciosis, oblongis, patentibus atque tarde elongatis; floribus 7–15, magnis, sepalis ovalis vel ovatis, obtusis, 14–17 mm. longis, 7–11 (vel. 13!) mm. latis, atro-caeruleis vel purpurascentibus, ab exteriore parte pallescentibus glabrisve, calcar subaequalibus, acutis, gracilis, petalis superioribus clavato-oblongis, albidis, inferioribus erosulatis atque retusis, suborbicularis, purpurascentibus, albo-villosulis; folliculis oblongis, subparallelibus vix divaricatisque, 11–14 mm. longis, ad

dorsum hirsutulosis, seminibus oblongis vel glandiformis 2 mm. longis, nigerrimis, impressis infirme angulatis similiter sordido-albidis alatis.

This species is probably highly localized. It grows on alpine rock slides or scree and is known only from Goat Rocks or Goat Mt., southeast of Mt. Rainier. It is unmistakably related closely to another little known endemic, *Delphinium glareosum* of the Olympics, from which it differs chiefly in characters of the inflorescence and flower size, as here tabulated:

Delphinium caprorum	*Delphinium glareosum*
Stems 15–20 cm. tall	*Stems* 22–38 cm. tall
Spur and sepals exteriorly lightly pubescent, not at all glandular	*Spur* and sepals exteriorly villose and more or less glandular
Pedicels a little villous just subtending the flower	*Pedicels* villous with conspicuous hairs, glandular for distal ½ of its length
Flowers 15–24 mm. long, very showy	*Flowers* 12–18 mm. long, moderately showy
Follicles hirsutulose dorsally	*Follicles* wholly glabrate
Based on type, *Thompson 15206*	*Based on* type, *Piper 2003* (Notre Dame Herb. 3334) and *H. E. & V. L. Bailey 293* (Ewan Herb.), ridge betw. Hayden Pass and Mt. Claywood, Mt. Olympus Nat. Mon.

This larkspur resembles *Delphinium glareosum* in its general habit, leaves, spreading pedicels and purplish-blue flowers. It is likewise a plant of scree slopes. *D. caprorum* is doubtless referred to by Piper (Fl. Wash. 280) when he places *Allen 146*, Goat Mt., under *D. bicolor*. That is not an alpine species, however, and differs in several particulars from either of these apparent relict species of Washington's older mountain summits.

3. D. NUDICAULE forma **elatium** (Thompson) Ewan, comb. nov., based on *D. nudicaule* var. *elatius* Thompson, Garden **19**: 234. 1881, in turn based on (?) garden plant, the "taller form with more leafy stems, the flowers rather longer with more slender spurs than in the typical state."

The English amateur gardener, William Thompson (1823–1903), drew the distinctions between typical *D. nudicaule* and forma *elatium* even before the date given above. In the periodical Garden, for June, 1873, vol. 3, p. 477, he itemized the observed distinctions as noted *in horto*. These should be given some field attention but at present there is no apparent phytogeographic significance in the distribution of forma *elatium*.

Typical *Delphinium nudicaule*	*D. nudicaule* forma *elatium*
Stems 3–6 dm. high, scarcely leafy	*Stems* 5–10 dm. high, leafy, giving a pyramidal aspect
Tubers rarely more than 5 cm. long	*Tubers* 12–20 cm. long, divergent
Flowers seldom more than 25 mm. long	*Flowers* 25–40 mm. long
Spur stout, short, curving	*Spur* slender, straighter
Petals more or less included	*Petals* rather distinctly exserted
Seeds numerous	*Seeds* few, "more than twice as large"

Representative collections: CALIFORNIA—MENDOCINO: Longvale, *S. W. Hutchinson 5587*. NAPA: Sarco Creek, 5 mi. above Napa, *Ewan 8662*. Forma *elatium* is apparently an established ecad, favoring brushy slopes associated

with *Ceanothus, Arctostaphylos, Symphoricarpos, Quercus garryana* and *Acer macrophyllum.*

4. D. PATENS subsp. **greenei** (Eastw.) Ewan, comb. nov., based on *D. greenei* Eastw., Bull. Torrey Club **28**: 674. 1901, in turn based on T. S. Brandegee coll., 29 V 1891, from Coburn Mills, s. Sierra Nevada, Fresno Co., Calif. TYPE (Calif. Acad. Sci. Herb. 232) studied.

5. D. PATENS subsp. **montanum** (Munz) Ewan, comb. nov., based on *D. parryi* var. *montanum* Munz, Bull. S. Calif. Acad. Sci. **31**: 61. 1932, in turn based on *Munz 6846,* Vincent Gulch, San Gabriel Mts., Los Angeles Co., Calif. TYPE (Pomona Coll. Herb. 18068) studied and type locality visited.

6. D. SCOPULORUM Gray, Fl. Wrightianae **2**: 9. 1853, based on *Charles Wright 842* from "mountain ravines near the Mimbres, New Mexico." Isotype (Phila. Acad. Nat. Sci.) studied and reproduced here as figure 1. This sheet is even a somewhat better representation than the TYPE (Gray Herb.).

More than thirty years ago E. O. Wooton expressed the view (Bull. Torrey Club **37**: 36. 1910) that "most of the material which has been passing as *D. scopulorum* is not very closely related to that species." The present author reiterated this view recently (Jour. Wash. Acad. Sci. **29**: 477. 1939). It is this prevalent misinterpretation that leads me to publish a photo of this apparently highly localized and distinctive *Delphinium.* There is at present no sound explanation to account for its erratic distribution. The only Colorado collection so far seen is *Parry 85* from "gravelly banks, dry ravines," July, 1862, with the generalization "Rocky Mts." From our knowledge of Parry's botanical activities in Colorado it can be placed more precisely as the Clear Creek watershed of central Colorado (cf. Ewan in April, 1941, *Trail and Timberline,* Colo. Mt. Club monthly). Identical in every respect is *Hall & Harbour 26* from the Rocky Mountains of Colorado, 1862. From the fact that these two collectors, Elihu Hall and J. P. Harbour, accompanied Parry during the season of 1862 is deduced this identity of specimens.

The relationships of *D. scopulorum* are with the species of the Mexican Sierra Madre Occidental, belonging to a wholly unrelated series from the more familiar and northern *D. occidentale* and *D. glaucum.* These northern *Delphiniums* are related to the Eurasian members of the Tribus *Elatopsis* of Huth. This phylogeny will be treated elsewhere. Meanwhile collectors are directed to true *D. scopulorum* in the hope that fruiting specimens will be taken from several stations in New Mexico and Colorado.

7. D. BURKEI Greene, Erythea **2**: 183. 1894, based on Burke coll., 1844–46, *sine numero,* from "Snake Country," that is, the Snake R. country of Idaho. TYPE at Kew; isotype should be looked for at Brit. Mus. Nat. Hist. *D. simplex* Dougl. ex Hook., Fl. Bor. Am. **1**: 25. 1829, based on Douglas coll. from "subalpine range, west of Rocky Mts., near the Columbia [R.]"; not *D. simplex* Salisb., 1796. Type (Kew Herb.) is pale-flowered form and was compared by

FIG. 1. Isotype of *Delphinium scopulorum* Gray.

Carl Epling with *Epling & Houck 9200*, Thatuna Hills, Ida., and annotated.

Delphinium burkei represents the larkspur still known by the preoccupied name *D. simplex* Dougl. Greene's specific name commemorates the British collector, Joseph Burke, who flourished between 1839 and 1846, botanizing in South Africa 1839–42, with Zeyher during 1840–41, and in North America 1844–46. Very little exact information exists regarding his

North American routes and movements (cf. Britten and Boulger, Biog. Index Brit. and Irish Bot. ed. 2. 1931). C. V. Piper, who in his Flora of Washington is usually informative on biographical items, does not mention Joseph Burke.

8. D. BURKEI subsp. **distichiflorum** (Hook.) Ewan, comb. nov., based on *D. simplex* var. *distichiflorum* Hook., London Jour. Bot. **6**: 67. 1847, in turn based on *Geyer 420* from high plains of Spokane and Nez Perces. Type in Herb. Hooker, Kew.

Those plants of *Delphinium burkei* with puberulent to wholly glabrous lower stems and leaves, the raceme densely compact, 30–45-flowered, is subsp. *distichiflorum*. It is apparently infrequent over the range of the species.

9. **D. umatillense** Ewan, sp. nov., based on *F. A. Warren 2089* from s. slope Madison Butte, Morrow Co., Oregon, 10 VIII 1937 and specimen in follicle, garden grown at Port Orchard, Wash., coll. 30 VI 1938. Type in Ewan Herb. at Univ. Colo.

Tall leafy perennial, 0.5–1.0 m. high, simple or branching from the base, arising from a woody fibrous clustered root, the stems green, slender, solid, puberulent and finely red flecked, rather evenly clothed with leaves, the leaves persistent at flowering time, ample, thin-textured, light green, the blades pentagonal, Acer-like flabelliform, 7–10 cm. wide, puberulent to glabrate, the primary segments cuneate, these again divided into lance-acuminate lobes, the ultimate segments acute; racemes oblong, rather open, 15–20-flowered, flowers 36–30 mm. long, on slender spreading pedicels, the sepals lanceolate, acuminate, puckered or crisped at tips, 11–13 mm. long, bright lively blue, yellowish below, the upper petals oblique rhomboid, entire and truncate, white on side, the lower petals uniformly light blue, the blades suborbicular, villous with curling white hairs; follicles nearly straight, erect or subparallel, venose, 14–16 mm. long, finely villous-pubescent, the cusps slender, erect; seeds dark, narrowly wing-margined, 2.0–2.5 mm. long, subtriquetrous.

Herba perennis caulibus erectis gracilibus, 0.5–1.0 m. altis, e radice tenui lignosa, simplicibus vel ramosis ad caulis basim, glabris vel puberulentis; foliis prorsus ad caulis distributis, pentapartitibus, segmentis cuneatis divisis lanceo-acuminatis, non filiformis ac brevioribus linearis, non mucronulatis; foliis caulibus aliquantulum reductis sed conspicuis, omnino puberulentis vel glabratis; racemis elongatis atque subpatentibus; floribus 26–30 mm. longis, pedicellis divaricatis, elatis, sepalis lanceolatis acuminatisve lucidis caeruleis et crispulis, 11–13 mm. longis, petalis superioribus rhomboidalis obliquisque integerrimis truncatisque, caeruleis in partim, albidis in partim, inferioribus suborbicularis omnino caeruleis et albo-villosis; folliculis suboblongibus, venosis, 14–16 mm. longis, villosulis, cuspide gracilibus, erectis, seminibus subtriquetris, 2.0–2.5 mm. longis, atrofuliginis impressis angulatis angustior similiter alatis.

Rocky mountain slopes and ridges, associated with *Juniperus occidentalis*, *Wyethia amplexicaulis*, *Balsamorrhiza sagittata* and species of *Artemisia*, of the arid Transition Zone of eastern Oregon. The type was taken in Umatilla National Forest on the upper slopes of the John Day River catchment basin, lying to the west of the Blue Mts.

The systematic position of this species can be best shown by a table contrasting *Delphinium umatillense* with *D. megacarpum*, known from this region, and *D. geyeri* of the plains and basins of more interior Idaho and eastward. Aside from their close morphology, then, these three related *Delphiniums* are likewise close geographic allies. (See table 1).

TABLE 1

Comparative morphology of three species of Delphinium

Characters	*D. megacarpum*	*D. umatillense*	*D. geyeri*
Stems	few-leaved, green cinereous-puberulent below	leafy, green, glabrous or nearly so	leafy, ashy pruinose-puberulent below
Basal leaves	suborbicular	Acer-like, flabelliform, pentagonal	Acer-like flabelliform, pentagonal
Base of primary segments of lvs.	cuneate	cuneate	subfiliform-linear
Base of petioles	conspicuously hirsute-ciliate	puberulent, not at all hairy	puberulent, not at all hairy
Flowers	dark-blue, rather densely racemose	bright lively blue, loosely racemose	bright lively blue, loosely to densely racemose
Sepals	"softly hirsute"	finely villous-puberulent, all lanceolate and acuminate	villose-puberulent, esp. medianly, the lateral sepals ovate, obtuse or apiculate
Spur	1⅓ as long as sepals, nearly straight	1½–2 times as long as sepals, curving and deflexed at tip (straight in bud)	1¼–1½ times as long as sepals, slightly deflexed at tip or nearly straight (upcurving in bud)
Follicles	venose, puberulent, 18–25 mm. long, closely erect and parallel	venose, finely villose, 14–16 mm. long, erect	venose, finely hirsutulose, 13–15 mm. long, erect or a little divergent
Seeds	dark, narrowly wing-margined	dark, narrowly wing-margined	columnar-pyramidal, strongly margined
Data based on	Type, *Nelson & Macbride 1779* (Univ. Wyo. Herb.)	Type, *F. A. Warren 2089* (Ewan Herb. at Univ. Colo.)	*Nelson 7340*, *Ewan 11262*, *Ramaley 16372*, and *Cockerell s. n.* (all Herb. Univ. Colo.)

It may be suggested that *Delphinium umatillense* is of hybrid origin following the establishment of *D. megacarpum* in its present range in eastern Oregon and at a time when *D. geyeri* ranged farther to the west than at present. By reference to table 1 it will be seen that *Delphinium umatillense* is morphologically more or less intermediate between the two described species, combining leaf characters of *D. megacarpum* with the flower color of *D. geyeri*.

UNIVERSITY OF COLORADO
BOULDER, COLORADO

BULLETIN OF THE TORREY BOTANICAL CLUB
69(2): 151–155 FEBRUARY, 1942

NEW NORTH AMERICAN UMBELLIFERAE

MILDRED E. MATHIAS AND LINCOLN CONSTANCE

Hydrocotyle bowlesioides Mathias & Constance, sp. nov. Caules graciles procumbentes hirsuti; folia non peltata, subrotundo-reniformia, ad basim sinu praedita, petiolis exclusis 1–2 cm. longa, 1.5–3 cm. lata, marginibus breviter 5-lobatis, lobis obtuse triangularibus crenatis subaequalibus, utrinque hirsutis; petiolus gracilis, 1–12 cm. longus, praecipue ad apicem versus reflexo-hirsutus; pedunculi 0.2–1.2 cm. longi, quam folia multo breviores, axillares graciles sparse hirsuti; umbellae non proliferae, globosae, 2–10-florae; styli persistentes; stylopodium depressum; fructus sessilis, in ambitu ellipticus, circa 1 mm. longus, 1.5 mm. latus, in intervallis minute hispidulus, costis manifestis, acutis subaequalibus.

Stems slender, creeping, hirsute; leaves not peltate, roundish-reniform with a sinus at the base, excluding the petiole 1–2 cm. long, 1.5–3 cm. broad, the margins shallowly 5-lobed, the lobes obtusely triangular, crenate, subequal, hirsute on both surfaces; petiole slender, 1–12 cm. long, reflexed-hirsute especially above; peduncles much shorter than the leaves, axillary, slender, 0.2–1.2 cm. long, sparsely hirsute; umbels not proliferous, 2–10-flowered, globose; the styles persistent; the stylopodium depressed; fruit sessile, elliptical in general outline, about 1 mm. long, 1.5 mm. broad, finely hispidulous in the intervals, the ribs evident, acute, subequal.

TYPE: *A. F. Skutch 3573*, wet pasture, Vara Blanca de Sarapiqui, north slope of Central Cordillera, between Poas and Barba volcanoes, Costa Rica, alt. 1740 m., February, 1938 (United States National Herbarium, No. 1,643,724).

This species is most closely allied to *H. Torresiana* Rose & Standl. by virtue of its shallowly lobed leaves, short peduncles and sessile fruit, but is clearly separable by its fewer leaf lobes and hispidulous fruit. Both species are endemic to the Central Cordillera of Costa Rica, *H. Torresiana* occurring to the south of *H. bowlesioides*, on Volcan de Turrialba. The specific name of the new entity indicates its superficial vegetative similarity to certain members of the genus *Bowlesia* Ruiz & Pavon.

Arracacia Schneideri Mathias & Constance, sp. nov. Herba crassa caulescens, ramosa, e radice magna carnosa, circa 8–10 dm. alta, foliis inflorescentibusque puberulis; folia in ambitu ovata, petiolis exclusis 1–1.5 dm. longa, circa 1 dm. lata, ternata deinde 1–2-pinnati, foliolis ex lanceolatis ad ovatos, ad apicem acutis, ad basim cuneatis, ex distinctis ad confluentes, plerumque sessilibus, 1–4 cm. longis, 0.1–1.5 cm. latis, acute serratis, rhachibus foliisque puberulis; petioli crassi, 7–10 cm. longi, ad basim vaginis latis; folia caulina basiliaribus similia, vaginis late dilatatis; inflorescentia pauciramosa, pedunculis non-nihil crassis, 8–9 cm. longis, dense puberulis; involucrum bractea unica foliacea, obsoletum; involucella bracteolae paucae inconspicuae ex lanceolatis ad filiformes integrae, 3–10 mm. longae, quam flores et fructus longiora vel breviora; radii fertiles crassi, 12–20, patenti-adscendentes subaequales, 2–3 cm. longi, dense puberuli; flores eburnei, petalis obovatis; stylopodium indistinctum depressum, stylis tenuis patentibus, ovario glabro; car-

pophorum bifidum; fructus ovato-oblongus, 7–8 mm. longus, 3–4 mm. latus, glaber ad apicem attenuatus, costis prominentissimis acutis; vittae magnae solitariae in valleculis, 2 in commissura; semina sub vittis canaliculata facie sulcata.

Stout, caulescent, branching, from a large fleshy root, about 8–10 dm. high, the foliage and inflorescence puberulent; leaves ovate in general outline, excluding the petioles 1–1.5 dm. long, about 1 dm. broad, ternate, then 1–2-pinnate, the leaflets lanceolate to ovate, acute at apex, cuneate at base, distinct to confluent and usually sessile, 1–4 cm. long, 0.5–1.5 cm. broad, sharply serrate, puberulent on the rachis and leaflets; petioles stout, 7–10 cm. long, broadly sheathing at base; cauline leaves like the basal, with broadly dilated sheaths; inflorescence sparingly branched, the peduncles rather stout, 8–9 cm. long, densely puberulent; involucre wanting, or of a foliaceous bract; involucel of several inconspicuous, lanceolate to filiform, entire bractlets, 3–10 mm. long, longer or shorter than the flowers and fruit; fertile rays stout, 12–20, spreading-ascending, subequal, 2–3 cm. long, densely puberulent; pedicels spreading-ascending, 4–6 mm. long, puberulent; flowers creamy-white, the petals obovate; stylopodium indistinct and depressed, the styles slender, spreading, the ovary glabrous; carpophore 2-cleft to the base; fruit ovate-oblong, 7–8 mm. long, 3–4 mm. broad, glabrous, tapering at apex, the ribs very prominent, acute; oil tubes large, solitary in the intervals, 2 on the commissure; seed deeply channeled under the tubes, the face sulcate.

TYPE: *R. A. Schneider 1051,* rocky slope at timberline, Cerro Potosi, Municipo de Galeana, Nuevo Leon, alt. 12,100 feet, August 4, 1938 (Herbarium of the Field Museum of Natural History, No. 958,958).

This species is a member of an anomalous group in the genus, characterized by the possession of a depressed and inconspicuous stylopodium, instead of the usual conical one. *Arracacia Schneideri* appears to be most closely related to *A. vaginata* Coult. & Rose, of southern Mexico, from which it may readily be distinguished by its more compound leaves, with acute leaflets, its conspicuously inflated cauline leaf sheaths, and its much more numerous fertile rays.

Oxypolis Greenmanii Mathias & Constance, sp. nov. Plantae 18–24 dm. altae; folia ad phyllodia septata fistulosa reducta, 2.5–4.5 dm. longa, vaginis 8–12 cm. longis; pedunculi 5–15 cm. longi; involucra bracteae plures lanceolato-acuminatae, 10–20 mm. longae; involucella bracteolae subulatae, 2–8 mm. longae; radii 16–19, patentes, paullo inaequales, 2.5–5 cm. longi (per anthesin); pedicelli patentes, 3–15 mm. longi; flores atropurpurei; calycis dentes conspicui; fructus non visus.

Plants 18–24 dm. high; leaves reduced to hollow, septate phyllodes, 2.5–4.5 dm. long, the sheaths 8–12 cm. long; peduncles 5–15 cm. long; involucre of several lanceolate-acuminate bracts 10–20 mm. long; involucel of subulate bractlets 2–8 mm. long; rays 16–19, spreading, slightly unequal, 2.5–5 cm. long (in flower); pedicels spreading, 3–15 mm. long; flowers dark purple; calyx teeth conspicuous; fruit not seen.

TYPE: *A. W. Chapman,* Wewahitchka, Gulf County, western Florida, August, 1896 (Herbarium of the Missouri Botanical Garden, No. 787,696).

Oxypolis filiformis (Walt.) Britt. is apparently the nearest relative of this species. In general, *O. Greenmanii* may be distinguished from *O. filiformis* by its greater stature, much larger phyllodes, more numerous rays

and deep purple flowers. Fruiting material is needed before the relationship between the two species can be properly judged. The species is named for Dr. J. M. Greenman, who first recognized its distinctness.

Lomatium Hamblenae Mathias & Constance, sp. nov. Plantae acaulescentes vel brevi-caulescentes, 1–3.5 dm. altae ex tubere globoso, circa 1.5 cm. diametro, glabrae; folia in ambitu obovata, petiolis exclusis 4–12 cm. longa, univel biternata, deinde pinnata vel pinnato-lobata, divisionibus ultimis remotis linearibus 5–23 mm. longis, 1–3 mm. latis acutis apiculatis; petiolus 2–5 cm. longus, scariosus vel late scarioso-marginatus ad basim vaginatus; pedunculi folia excedentes; involucella bracteolae paucae, inconspicuae lineares lanceolataeve, distinctae connataeve quam pedicelli plurimum breviores; radii 2–8, adscendentes, 4–8 cm. longi inaequales; pedicelli 15–25 cm. longi, umbellulis 10–15-floris; flores claro-lutei; fructus lineari-oblongus, 4–7 mm. longus, 2–3 mm. latus, glaber, alis quam corpore multo angustioribus.

Plants acaulescent or short-caulescent, 1–3.5 dm. high, from a globose tuber about 1.5 cm. in diameter, glabrous; leaves obovate in general outline, excluding the petiole 4–12 cm. long, once or twice ternate, then pinnate or pinnately lobed, the ultimate divisions remote, linear, 5–23 mm. long, 1–3 mm. broad, acute, apiculate; petioles 2–5 cm. long, scarious or broadly scarious-margined, sheathing at base; peduncles exceeding the leaves, involucel of a few, inconspicuous, linear or lanceolate bractlets, distinct or connate, very much shorter than the pedicels; rays 2–8, ascending, 4–8 cm. long, unequal; pedicels 15–25 mm. long, the umbellets 10–15-flowered; flowers bright yellow; fruit linear-oblong, 4–7 mm. long, 2–3 mm. broad, glabrous, the wings much narrower than the body.

TYPE: *Frances G. Hamblen* (*Mrs. L. R.*), on level scab-rock bench at Dry Falls, Grand Coulee, Washington, 1941 (Herbarium of the University of California).

The other bulbous yellow-flowered species do not seem to be closely related to the present species. The foliage, slender habit, nearly filiform, elongated pedicels and slender fruit point to an affinity with certain of the white-flowered species, notably *L. farinosum* (Geyer) Coult. & Rose.

LOMATIUM CILIOLATUM Jepson var. **Hooveri** Mathias & Constance, var. nov. Varietas speciei similis, multo gracilior, 1.5–3 dm. alta, dense scaberula; folia 6–13 cm. longa, divisionibus (lobis) ultimis linearibus, 1–10 mm. longis, non plus quam 1 mm. latis; petioli 3–7 cm. longi; pedunculi 8–25 cm. longi; radii 3–14, 3–10 cm. longi; pedicelli 3–8 mm. longi; fructus alae tenues.

Like the species, but much more slender throughout, 1.5–3 dm. high, densely scaberulous; leaves 6–13 cm. long, the ultimate divisions or lobes linear, 1–10 mm. long, 1 mm. or less broad; petioles 3–7 cm. long; peduncles 8–25 cm. long; rays 3–14, 3–10 cm. long; pedicels 3–8 mm. long; fruit wings thin.

TYPE: *Mathias 1298*, rocky hillside, 1.9 miles southeast of Napa-Lake County line, on road to Knoxville, Napa County, California, May 23, 1937 (Herbarium of the University of California).

Specimens examined: CALIFORNIA: just east of Lake County line on Williams–Clear Lake highway, Colusa County, May 2, 1941, *R. F. Hoover 4987*.

The pubescence, conspicuous bractlets and purple flowers relate this

variety closely to the species, of which it is apparently a more slender phase of lower altitudes. The foliage is very similar to that of the following species.

Lomatium Tracyi Mathias & Constance, sp. nov. Plantae acaulescentes, 1–3.5 dm. altae, ex glabris ad sparse scaberulo-puberulas, e radice primaria longa tenui; folia in ambitu ex oblongis ad ovata, petiolis exclusis 4–10 cm. longa, ternata deinde 1–2-pinnata, divisionibus ultimis ex linearibus ad oblongos acutis obtusisve, apiculatis, 1–7 mm. longis, 0.4–2 mm. latis; petiolus 2–5 cm. longus, scariosus ex toto vaginatus; pedunculi folia excedentes; involucella bracteolae ex oblonceolatis ad lineares acuminatae saepe petiolulatae, scarioso-marginatae, flores subaequantia; radii 4–9 (fertiles 1–6) inaequales, stricte adscendentes glabri vel scaberuli, 0.5–8 cm. longi; pedicelli 1–5 mm. longi, eorum pauci fertiles; umbellulae 10–15-florae; flores lutei; fructus ex oblongo-ovato ad ovalem, 6–10 mm. longus, 3–5 mm. latus, ad basim et ad apicem plerumque acutus, glaber, alis tenuibus quam corpore multo angustioribus; vittae obscurae.

Plants acaulescent, 1–3.5 dm. high, from a long, slender taproot, glabrous to sparsely scaberulous-puberulent; leaves oblong to ovate in general outline, excluding the petiole 4–10 cm. long, ternate, then 1–2-pinnate, the ultimate divisions linear to oblong, acute or obtuse, apiculate, 1–7 mm. long, 0.4–2 mm. broad; petiole 2–5 cm. long, scarious, wholly sheathing; peduncles exceeding the leaves; involucel of oblanceolate to linear, acuminate, often petiolulate, scarious-margined bractlets, about equalling the flowers; rays 4–9 (the fertile 1–6), strictly ascending, 0.5–8 cm. long, very unequal, glabrous or scaberulous; pedicels 1–5 mm. long, few fertile, the umbellets 10–15-flowered; flowers yellow; fruit oblong-ovate to oval, 6–10 mm. long, 3–5 mm. broad, usually acute at the base and the apex, glabrous, the wings thin, much narrower than the body; oil tubes obscure.

TYPE: *J. P. Tracy 12,895* serpentine gravel flats, especially under yellow pines, Grouse Mountain, Humboldt County, California, alt. 5000 feet, July 25, 1933 (Herbarium of the University of California).

Specimens examined: CALIFORNIA–HUMBOLDT: in open forest of Jeffrey pine, on red soil in serpentine belt, Horse Mountain, alt. about 5000 feet, June 20, 1936, *Tracy 7610;* under yellow pines, serpentine soil, Brannan Mountain, alt. 4000 feet, July 10, 1930, *Tracy 8869;* in gravelly soil, open situations, Mary Blaine Mountain, alt. 6400 feet, August 3, 1935, *Tracy 14,462;* red serpentine soil, French Camp Ridge, alt. 3500 feet, June 23, 1935, *Tracy 13,971.* TRINITY: near summit on Weaverville road, yellow pine forest, Hay Fork Mountain, alt. 3600 ft., June 30, 1923, *Tracy 6457;* openings among yellow pines, Burnt Ranch, alt. 1500 feet, June 28, 1923, *Tracy 6393.*

The group of species which comprises *L. caruifolium* (H. & A.) Coult. & Rose—with which the present species has been confused, *L. marginatum* (Benth.) Coult. & Rose and *L. ciliolatum* Jepson, has given a great deal of trouble to everyone attempting to construct a treatment of the genus. The separation of *L. Tracyi* will, we believe, make possible a more precise delimitation of *L. caruifolium,* and hence facilitate the erection of clearer specific boundaries within this group. From *L. caruifolium, L. Tracyi* differs in its lower stature, more slender habit, fewer rays, reduced involucel and sparser and usually narrower fruit, as well as in its higher altitudinal range and more northerly distribution.

Lomatium Peckianum Mathias & Constance, sp. nov. Plantae acaulescentes, 1–1.5 dm. altae, e scaberulis ad glabras, e radice primaria longa tenuissima; folia in ambitu ovato-oblonga, petiolis exclusis 2.5–5.5 cm. longa, ternata deinde 1–2-ternata, divisionibus ultimis e remotis ad confluentes, ex oblongis ad lineares, apiculatis, 1–18 mm. longis, 0.5–1.5 mm. latis; petiolus 2–4 cm. longus, laminae subaequalis, scarioso-marginatus ex toto vaginatus; pedunculi ex vaginis foliorum procedentes, folia excedentes, 6–10 cm. longi; involucella bracteolae obsoletae vel paucae, inconspicuae distinctae lineares subacuminatae subscariosae, pedicellis breviora; radii obsoleti vel 1–3, inaequales adscendentes, ad 3 cm. longi; pedicelli 2–7 mm. longi; plerumque una umbellula sessilis sterilis; umbellularum flores fertiles 1–7, steriles pauci; flores non visi; ovaria granulato-aspera; fructus oblongo-ovalis 2–13 mm. longus, 4–5.5 mm. latus, ex granulato-aspero ad glabratum, ad basim et ad apicem versus attenuatus, alis quam corpore minoribus dimido latitudine; vittae obscurae in commissura 6–8, in valliculis paucae.

Plants acaulescent, 1–1.5 dm. high, from a long, very slender taproot, scaberulous to glabrous; leaves ovate-oblong in general outline, excluding the petiole 2.5–5.5 cm. long, ternate, then 1–2-ternate, the ultimate divisions remote to confluent, oblong to linear, 1–18 mm. long, 0.5–1.5 mm. broad, apiculate; petiole 2–4 cm. long, about equalling the blade, scarious-margined, wholly sheathing; peduncles arising from a cluster of leaf sheaths, exceeding the leaves, 6–10 cm. long; involucel wanting, or of a few, inconspicuous, distinct, linear, subacuminate, subscarious bractlets, shorter than the pedicels; rays 1–3, ascending, obsolete to 3 cm. long, very unequal; pedicels 2–7 mm. long, the umbellets with 1–7 fertile flowers and a few sterile flowers, one umbellet usually sessile, sterile; flowers not seen, the ovaries granulate-roughened; fruit oblong-oval, 2–13 mm. long, 4–5.5 mm. broad, granulate-roughened to glabrate, narrower toward the base and the apex, the wings less than one-half the width of the body; oil tubes obscure, several in the intervals, about 6–8 on the commissure.

TYPE: *M. E. Peck 15,213*, dry sterile hillside three miles east of Blye, Klamath County, Oregon, June 25, 1927 (Herbarium of Willamette University).

The granulate-roughened young fruit would seem to relate this species to *L. Sandbergii* Coult. & Rose, which it does not otherwise closely resemble. It is perhaps more nearly allied to *L. nevadense* (Wats.) Coult. & Rose than to any other species, but is adequately distinct because of its ternately compound leaves, wholly sheathing petioles, inconspicuous involucel, few rays and more slender fruit.

We wish to express our gratitude to Miss Ethel K. Crum, Assistant Curator of the Herbarium of the University of California, for preparing the Latin diagnoses for this and other papers. We are also grateful to the curators of the herbaria mentioned for the opportunity to see the material cited. All collections listed, with the exception of the type specimens, are in the Herbarium of the University of California.

DEPARTMENT OF BOTANY, UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

BULLETIN OF THE TORREY BOTANICAL CLUB
69(2): 156–161 FEBRUARY, 1942

SUPPLEMENTARY NOTES ON AMERICAN MENISPERMACEAE—II

B. A. KRUKOFF AND H. N. MOLDENKE

Through the courtesy of the curators of the two Brazilian botanical institutions mentioned below we were privileged recently to study their collections of the Menispermaceae. Most of these collections are not represented by duplicates outside of Brazil. They were found to be of considerable interest and are discussed in the present paper. The collections examined extend our knowledge of certain species previously known from incomplete material, extensions of ranges are noted for a number of species, and one species is described as new. No changes in the nomenclature are necessitated.

The species are arranged in the same order and the place of deposit of specimens is shown by the same abbreviations as in our previous papers (1, 2, 3). The following new abbreviations are used:

PG: Museo Goeldi de Historia Natural e Ethnographia, Pará, Brazil.

SP: Departamento de Botanica do Estado de São Paulo, Brazil.

Ven: Herbario del Museo Comercial de Venezuela, Caracas, Venezuela.

The majority of collections from the Museo Goeldi are without collectors' numbers. Thus, it has been found necessary to cite them under the numbers that were assigned to them at that institution. The abbreviation "H.A.M.P." stands for Herbarium Amazonicum Musei Paraensis.

CHONDODENDRON Ruíz & Pavon

2. CHONDODENDRON PLATIPHYLLUM (A. St. Hil.) Miers. *Additional specimens examined:* BRAZIL—RIO DE JANEIRO: *Glaziou 9348* (PG). SÃO PAULO: *Dept. Bot. São Paulo 12985* (SP).

This is the first record of the species from the State of São Paulo.

5. CHONDODENDRON LIMACIIFOLIUM (Diels) Moldenke. *Additional specimens examined:* BRAZIL—PARÁ: *Sigueira s.n.* (*H.A.M.P. 8266*) (PG—isotype); *collector undesignated s.n.* (*H.A.M.P. 9565*) (PG), *s.n.* (*H.A.M.P. 10178*) (PG).

The common name "abuta" is recorded for specimens from Pará. In our previous paper (1: 22) we stated that fruits of only four species of *Chondodendron* (namely *C. tomentosum, C. toxicoferum, C. tomentocarpum* and *C. platiphyllum*) were available to us for examination. The above cited specimen (*H.A.M.P. 10178*) of *C. limaciifolium* is in fruit, which is here described for the first time. It is now evident that the fruits of this species are larger than those of *Chondodendron toxicoferum* (*Krukoff 4754* and *H.A.M.P. 4286*), which are about 2 cm. long and 1 cm. wide.

Infructescence racemiform; fruiting peduncles and rachis stout, densely incanous-tomentellous, often greatly abbreviated; fruiting pedicels stout,

1–2.5 cm. long, densely incanous-tomentellous; torus greatly expanded and club-shaped in fruit, 4–5 mm. in diameter; fruit elliptic, symmetric, basally attached, 2.5–2.8 cm. long, 2.1–2.4 cm. wide, rounded at both ends, the exocarp densely flavescent- or sordid-tomentellous, the mesocarp thin, rather woody, the endocarp thin and roughened.

7. CHONDODENDRON TOXICOFERUM (Wedd.) Krukoff & Moldenke. *Additional specimens examined:* BRAZIL: basin of Rio Jurua, *Ule 5631* (type coll. of *C. polyanthum*) (PG). AMAZONAS: basin of Rio Iça, *Ducke s.n.* (*H.A.M.P. 7657*) (PG). ACRE TERRITORY: basin of Rio Acre, *Huber s.n.* (*H.A.M.P. 4286*) (PG).

SCIADOTENIA Miers

1. SCIADOTENIA SAGOTIANA (Eichl.) Diels. *Additional specimens examined:* BRAZIL—PARÁ: *Goeldi s.n.* (*H.A.M.P. 3239*) (PG); *dos Santos s.n.* (*H.A.M.P. 7290*) (PG).

The common name "abuta miry" is recorded for the specimen collected by dos Santos. The species has been known hitherto only from the type collection from French Guiana. The fruits are here described for the first time.

Infructescence dichotomously branched, the branches usually very short; fruiting-peduncles slender, 1.3–2 cm. long, densely cinereous-tomentellous; fruiting pedicels about 3 mm. long, incrassate, densely cinereous-tomentellous, the torus not expanded; fruit obovate, symmetric, basally attached, 1–1.5 mm. long, 7–9 mm. wide, rounded at apex, narrowed to the base, the exocarp very densely puberulent, wrinkled, the mesocarp very thin and probably fleshy when fresh, the endocarp papery, glabrous, very shiny.

2. SCIADOTENIA PARAËNSIS (Eichl.) Diels. *Additional specimen examined:* BRAZIL—AMAZONAS: basin of Rio Jamunda, *Ducke s.n.* (*H.A.M.P. 15685*) (PG).

This is the first record of the species from the State of Amazonas.

8. SCIADOTENIA AMAZONICA Eichl. *Additional specimen examined:* PERU—LORETO: near Iquitos, *Ducke s.n.* (*H.A.M.P. 7588*) (PG).

This is the second collection of the species and the first record of it from Peru. The specimen is the first one known with staminate inflorescences. A description of the flowers follows: staminate flowers: sepals 18, closely imbricate, varying in size, arranged in sets of 3, the outermost set smallest, lanceolate, about 1.2 mm. long and 0.4 mm. wide, gradually attenuate to the apex, the innermost set largest, elliptic, about 2.5 mm. long and 0.8 mm. wide, acuminate at the apex, all densely villous on the back and margins; petals 6, subequal, oblanceolate, about 1.6 mm. long and 0.5 mm. wide above the middle, thin-textured along the margins, thickened in a median ridge, acute at apex, slightly concave, densely villous on the back and margins; stamens 6, free, three longer and stouter than the other three, the glabrous filaments conspicuously ampliate at the apex.

9. SCIADOTENIA CAYENNENSIS Benth. *Additional specimens examined:* BRAZIL—PARÁ: *Huber s.n.* (*H.A.M.P. 519*) (PG); basin of Rio Trombetas, *Ducke s.n.* (*H.A.M.P. 15886*) (PG).

Ducke's specimen is the first record of the species from the basin of Rio Trombetas. He records on the label: "Large vine. Fruits are orange in color."

10. SCIADOTENIA BRACHYPODA Diels. *Additional specimens examined:* BRAZIL—AMAZONAS: basin of Rio Purus, *Goeldi s.n.* (*H.A.M.P. 3934*) (PG—type); basin of Rio Içá, *Ducke s.n.* (*H.A.M.P. 7694*) (PG).

12. SCIADOTENIA SPRUCEI Diels. *Additional specimens examined:* BRAZIL—PARÁ: *Miles Moss 90* (W); basin of Rio Tapajoz, *Ducke s.n.* (*H.A.M.P. 16761*) (PG).

The species has been known hitherto only from two collections from the basin of Rio Negro, State of Amazonas. Ducke's specimen is remarkable for its comparatively large leaves resembling in shape those of *S. brachypoda.* The collector states: "flowers yellowish."

ANOMOSPERMUM Miers

1. ANOMOSPERMUM SCHOMBURGKII Miers. *Additional specimens examined:* BRAZIL—ACRE TERRITORY: Rio Branco, *Ule 7702* (*H.A.M.P. 12809*) (PG). PARÁ: Collares, *Ducke s.n.* (*H.A.M.P. 12616*) (PG). CEARÁ: *Ducke s.n.* (*H.A.M.P. 1503*) (PG); *Huber s.n.* (*H.A.M.P. 1862*) (PG).

3. ANOMOSPERMUM RETICULATUM (Mart.) Eichl. *Additional specimens examined:* BRAZIL—AMAZONAS: basin of Rio Içá, *Ducke s.n.* (*H.A.M.P. 7716*) (PG). PARÁ: basin of Rio Xingu, *Bach s.n.* (*H.A.M.P. 4149*) (PG).

The Bach specimen is the first record of the species from the State of Pará. The fruits are here described for the first time. Fruiting pedicels stout, about 1 cm. long, short-pubescent; torus club-shaped in fruit, conspicuously expanded to 4 mm. in diameter; fruit asymmetric, ovate, basally attached, about 3 cm. long and 2 cm. wide, the exocarp more or less pustulate-roughened except at the smooth and shiny points of contact, the mesocarp very thick, hard, and bony.

6. ANOMOSPERMUM CHLORANTHUM Diels. *Additional specimen examined:* BRAZIL—ACRE TERRITORY: basin of Rio Acre, *Ule 9388* (PG—isotype).

TELITOXICUM Moldenke

1. TELITOXICUM KRUKOVII Moldenke. *Additional specimen examined:* BRAZIL—PARÁ: basin of Rio Curua, *LeCointe s.n.* (*H.A.M.P. 17301*) (PG).

The common name "cipo lingua" is recorded by LeCointe. The species has been known hitherto only from the type collection from the basin of Rio Madeira, State of Amazonas.

3. TELITOXICUM INOPINATUM Moldenke. *Additional specimen examined:* BRAZIL—PARÁ: near Almeirim, *Ducke s.n.* (*H.A.M.P. 17261*) (PG).

This is the first record of the species from Brazil.

5. TELITOXICUM DUCKEI (Diels) Moldenke. *Additional specimen examined:* BRAZIL—PARÁ: basin of Rio Mapuera, *Ducke s.n.* (*H.A.M.P. 9012*) (PG—isotype).

6. TELITOXICUM MINUTIFLORUM (Diels) Moldenke. *Additional specimen examined:* BRAZIL—AMAZONAS: basin of Rio Negro, *Froes 11998* (N).

ABUTA Barrère

2. ABUTA OBOVATA Diels. *Additional specimen examined:* BRAZIL—AMAZONAS: basin of Rio Negro, *Froes 11997* (N).

This is the first record of the species from Brazil.

5. ABUTA VELUTINA Gleason. *Additional specimen examined:* BRAZIL—AMAZONAS: basin of Rio Negro, *Froes 12001* (N).

This is the first record of the species from Brazil. It has been known hitherto only from the type collection from Venezuela.

8. ABUTA IMENE (Mart.) Eichl. *Additional specimen examined:* BRAZIL—PARÁ: basin of Rio Jamunda, *Ducke s.n.* (*H.A.M.P. 11723*) (PG).

This is the first record of the species from the State of Pará.

9. ABUTA COLOMBIANA Moldenke. *Additional specimen examined:* BRAZIL—AMAZONAS: basin of Rio Iça, *Ducke s.n.* (*H.A.M.P. 7708*) (PG).

This specimen is placed here tentatively. Its inflorescences are pistillate and only staminate inflorescences have been seen hitherto of this species. Neither are pistillate inflorescences available of the obviously related *A. grandifolia*, so that comparisons cannot be made. The foliar characters of our specimen, however, match so perfectly those of *A. colombiana* and so poorly those of *A. grandifolia*, that it seems most probable that it represents the first Brazilian collection of the former species. A brief description of the flowers is given herewith: pistillate flowers: sepals 6, the outer 3 small, lanceolate, about 0.7 mm. long and 0.3 mm. wide, attenuate from the base to the acute apex, minutely puberulent on the back, the inner 3 much larger, broadly ovate or subrotund, about 1.5 mm. long and wide, rounded to a very short subacute point at the apex, rounded or subcordate at base, densely short-puberulent on the back; carpels 3, densely appressed-pubescent.

11. ABUTA GRANDIFOLIA (Mart.) Sandw. *Additional specimens examined:* VENEZUELA—BOLÍVAR: *Ll. Williams 11437* (Ven). BRAZIL—MATTO GROSSO: *Dep. Bot. São Paulo 8185* (SP). ACRE TERRITORY: basin of Rio Acre, *Ule 9386* (PG), *9387* (PG). AMAZONAS: basin of Rio Purus, *Huber s.n.* (*H.A.M.P. 4414*) (PG), *s.n.* (*H.A.M.P. 4639*) (PG); basin of Rio Iça, *Ducke s.n.* (*H.A.M.P. 7641*), *s.n.* (*H.A.M.P. 7689*) (PG); basin of Rio Negro, *Krukoff 12104* (N); *Froes 11999* (N). PARÁ: basin of Rio Tapajoz, *Ducke s.n.* (*H.A.M.P. 15817*) (PG); basin of Rio Jamauchim, *Snethlage s.n.* (*H.A.M.P. 10105*) (PG); basin of Rio Ariramba, *Ducke s.n.* (*H.A.M.P. 11319*) (PG), *s.n.* (*H.A.M.P. 8056*) (PG); Bragança, *collector undesignated s.n.* (*H.A.M.P. 9808*) (PG); Oriximina, *Ducke s.n.* (*H.A.M.P. 7868*) (PG); Murutucú, *Rodriguez s.n.* (*H.A.M.P. 2820*) (PG); Almerim, *Ducke s.n.* (*H.A.M.P. 3060*) (PG), *s.n.* (*H.A.M.P. 3454*) (PG).

13. ABUTA SELLOANA Eichl. *Additional specimens examined:* BRAZIL—SÃO PAULO: *Dep. Bot. São Paulo 946* (N, SP), *12986* (SP), *12988* (N, SP), *19627* (SP), *28429* (N. SP). MATTO GROSSO: *Dep. Bot. São Paulo 8184* (SP).

This is the first record of the species from the State of Matto Grosso. The common name "quina brava" is recorded for specimens from the State of São Paulo.

14. ABUTA RUFESCENS Aubl. *Additional specimens examined:* BRAZIL—AMAZONAS: basin of Rio Negro, *Krukoff 12105* (N); *Froes 12000* (N).

The above specimens are the first record of the species from the basin of Rio Negro.

16. ABUTA GRISEBACHII Triana & Planch. *Additional specimen examined:* BRAZIL—AMAZONAS: basin of Rio Negro, *Froes 12002* (N).

17. ABUTA CANDOLLEI Triana & Planch. *Additional specimen examined:* BRAZIL—PARÁ: near Obidos, *Ducke s.n.* (*H.A.M.P. 2897*) (PG).

This specimen exhibits staminate flowers whose inner petals are considerably larger than in any previously examined and cited material. The inner petals here are broadly elliptic, about 2.4 mm. long and 1.7 mm. wide.

19. **Abuta brevifolia** Krukoff & Moldenke, sp. nov. Frutex scandens; ramulis gracilibus glabris vel leviter cinereo-pulverulentis; petiolis 7–15 mm. longis, ad apicem valde incrassatis; laminis foliorum coriaceis ellipticis 3.3–7 cm. longis, 2.3–5 cm. latis, ad apicem acutis vel brevissime acuminatis vel obtusis, ad basin rotundatis vel subacutis, subrevolutis, supra subglabris nitidis, subtus obscure pulverulento-puberulis vel subglabris nitidis, 3-plinerviis; infructescentiis axillaribus vel supra-axillaribus racemiformibus foliosis geminatis leviter puberulis.

Description: A woody vine; branchlets slender, glabrous or lightly cinereous-pulverulent; petioles 7–15 mm. long, conspicuously incrassate at apex, lightly puberulent; leaf-blades coriaceous, elliptic, 3.3–7 cm. long, 2.3–5 cm. wide, acute or very shortly acuminate at apex, varying to obtuse, entire and somewhat revolute along the margins, rounded or subacute at base, subglabrous and shiny above, obscurely pulverulent-puberulent or subglabrous and shiny beneath, 3-plinerved; midrib and primary veins very slightly subimpressed above, sharply prominent beneath, the primaries issuing a few mm. above the base of the blade; secondaries numerous, issuing rather irregularly at right angles to the primaries, subparallel to each other, prominulous above, more sharply so beneath; veinlet reticulation rather abundant, obscure above, rather distinct under a hand-lens beneath; inflorescence not seen; infructescence axillary or supra-axillary, racemiform, leafy, borne in pairs, far surpassing the subtending leaves; fruiting peduncles rather slender, 3.5–4 cm. long, lightly puberulent; rachis similar to the peduncles in all respects, 11–12 cm. long, bearing several rather distant leaves and fruits; fruiting pedicels slender, 6–10 mm. long, appressed-puberulent; torus greatly expanded and club-shaped in fruit, 3–3.5 mm. in diameter; fruit oblong, asymmetric, sublaterally attached, about 2 cm. long and 1.3 cm. wide, the exocarp lightly pulverulent and venose, the mesocarp rather thick, very hard and bony, the endocarp thin, stramineous and shiny.

The type specimen has its branchlets, petioles, and infructescences more or less densely covered with a cinereous and closely appressed growth of a species of mold, imparting to the plant a very conspicuous but deceptive ashy-gray appearance. The collection was cited by Diels (4: 197) in remarks under *A. guyanensis* Eichl. [= *A. grandifolia* (Mart.) Sandw.].

Specimen examined: BRAZIL—PARÁ: basin of Rio Mapuera, *Ducke s.n.* (*H.A.M.P. 8976*) (PG—TYPE).

ELISSARRHENA Miers

1. ELISSARRHENA GRANDIFOLIA (Eichl.) Diels. *Additional specimens examined:* BRAZIL—ACRE TERRITORY: basin of Rio Jurua, *Ule 5526* (type coll. of *Anomospermum Ulei*) (PG); basin of Rio Purus, *Ule 9389* (PG).

THE NEW YORK BOTANICAL GARDEN
NEW YORK

Literature Cited

1. **Krukoff, B. A. & Moldenke, H. N.** Studies of American Menispermaceae, with special reference to species used in preparation of arrow-poisons. Brittonia **3**: 1–74. 1938.
2. ————————. A new name for *Cocculus toxicoferus* Wedd. Brittonia **3**: 338. 1939.
3. ————————. Supplementary notes on American Menispermaceae. Bull. Torrey Club **68**: 237–243. 1941.
4. **Diels, L.** Menispermaceae. *In* Engler, A. Das Pflanzenreich **4** (94): 1–345. 1910.

INDEX TO AMERICAN BOTANICAL LITERATURE

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Papers that relate exclusively to bacteriology, forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

PLANT TAXONOMY AND FLORISTICS
(exclusive of fungi)

Bailey, L. H. Species *Batorum*. The genus *Rubus* in North America (north of Mexico). III. Section 4. Setosi. Northern Bristle-berries. Gentes Herb. **5**: 129–198. *pl. 50–83*. O 1941.

Barneby, R. C. A new species of *Cymopterus* from Nevada. Leafl. West. Bot. **3**: 81–83. 6 N 1941.

Blake, S. F. Note on the name *Eupatorium rugosum*. Rhodora **43**: 557–558. *pl. 672*. N 1941.

Bondar, G. Palmeiras do genero cocos e descrição de daus especies novas. Inst. Cent. Fom. Econ. Bahia Bull. no. 9: 1–53. *f. 1–13*. 1941.

Bruce, E. A. & Bally, P. R. O. Some new species of Stapelieae from East Africa. Cactus & Succ. Jour. **13**: 165–168. *fig. 102–106*. O 1941.

Bruce, E. A. & Bally, P. R. O. Some new species of Stapelieae and Ceropegieae from East Africa. Cactus & Succ. Jour. **13**: 179–181. *fig. 114–116*. N 1941.

Camp, W. H. Studies in the Ericales: A review of the North American Gaylussacieae; with remarks on the origin and migration of the group. Bull. Torrey Club **68**: 531–551. 1 N 1941.

Carabia, J. P. Las Bromeliaceas de Cuba III. Mem. Soc. Cub. Hist. Nat. **15**: 265–279. O 1941.

Cárdenas, M. Algunos vegetales curiosos de Bolivia. *In* Contrib. Flora Bolivia. Univ. Simon Bolivar. 11–14. 1941.

Cárdenas, M. Estado actual de la quinologia Boliviana. *In* Contrib. Flora Bolivia. Univ. Simon Bolivar. 15–26. 1941.

Cárdenas, M. Los cactus de los alrededores de la Ciudad de la Paz. *In* Contrib. Flora Bolivia. Univ. Simon Bolivar. 33–36. 1941.

Cárdenas, M. Notas sobre frutas silvestres comestibles de Bolivia. *In* Contrib. Flora Bolivia. Univ. Simon Bolivar. 27–32. 1941.

Cárdenas, M. Recursos naturales del reino vegetal en Bolivia. Chron. Bot. **6**: 404–406. N 1941.

Clausen, R. T. The variations of *Sagittaria subulata*. Torreya **41**: 161, 162. 30 O 1941.

Cuatrecasas, J. Notas a la Flora de Colombia. III. Rev. Acad. Colomb. **4**: 158–169. *pl. 1–4* + *f. 1–12*. Jl–Au 1941.

Dansereau, P. Notes sur les Cistes. I. La collection du Bailey Hortorium. Contr. Inst. Bot. Univ. Montreal No. 37: 5–14. 1941.

Dansereau, P. & Lafond, A. Introgression des caractères de l'*Acer Saccharophorum* K. Koch et de l'*Acer nigrum* Michx. Contr. Inst. Bot. Univ. Montreal No. 37: 15–31. *f. 1–5.* 1941.

Dunkle, M. B. Two new plants from the Channel Islands of California. Contributions from the Los Angeles Museum—Channel Islands Biological Survey. No. 21. Bull. So. Cal. Acad. Sci. **40:** 108, 109. 25 O 1941.

Eastwood, A. New species of *Castilleja.* Leafl. West. Bot. **3:** 87–92. 6 N 1941.

Epling, C. Supplementary notes on American Labiatae—II. Bull. Torrey Club **68:** 552–568. 1 N 1941.

Fosberg, F. R. & Walker, E. H. A preliminary check list of plants in the Shenandoah National Park, Virginia. Castanea **6:** 89–136. O–N 1941.

Goodspeed, T. H. Geographic distribution of the Chilean members of the genus *Nicotiana.* Rev. Univ. (Chile) **26:** 115–130. N 1941.

Harrison, A. K. Another Massachusetts station for *Serapias Helleborine.* Rhodora **43:** 632. N 1941.

Heller, A. A. *Lupinus* studies. II. Leafl. West. Bot. **3:** 92–94. 6 N 1941.

Hester, J. P. *Coryphantha fragrans* sp. nov. Desert **13:** 152, 153. O 1941.

Hodge, W. H. The vegetation of the Lesser Antilles, a brief review. Chron. Bot. **6:** 402–404. N 1941.

Howell, J. T. *Lamium purpureum* L. Leafl. West. Bot. **3:** 96. 6 N 1941.

Howell, J. T. Studies in *Phacelia*—I. Leafl. West. Bot. **3:** 95, 96. 6 N 1941.

Jaccard, P. Sur le coefficient générique II. Chron. Bot. **6:** 389–391. N 1941.

Lang, W. B. Mosses in the Virginia caverns. Science **94:** 414. 31 O 1941.

Maguire, B. Weed records for the Great Basin. Torreya **41:** 164–166. 30 O 1941.

Moldenke, H. N. Chile Tarweed east of the Mississippi. Torreya **41:** 162–164. 30 O 1941.

Munz, P. A. Interesting western plants—VI. Leafl. West. Bot. **3:** 83–87. 6 N 1941.

Munz, P. A. Onagraceae of Nevada. *In* Contributions toward flora of Nevada. No. 32. U. S. Dept. Agr. Div. Plant Exploration. Bur. Plant Ind. 73 mimeog. pages. Washington, 1 N 1941.

Murrill, W. A. A Florida white blackberry. Science **94:** 326. 3 O 1941.

Randhawa, M. S. Notes on three species of *Oedocladium* from the Himalayas. Trans. Am. Micros. Soc. **60:** 417–420. *pl. 1.* O 1941.

Rosengurth G., B. La vegetación del Uruguay. Chron. Bot. **6:** 410, 411. N. 1941.

Rush, E. *Sedum confusum* Hemsley, rediscovered. Cactus & Succ. Jour. **13:** 146–148. *f. 86–88.* S 1941.

Schultes, R. E. A contribution to our knowledge of *Rivea corymbosa* the narcotic ololiuqui of the Aztecs. 1–45. *illust.* Bot. Museum Harvard, Cambridge. 1941.

Sherff, E. E. Additions to our knowledge of the American and Hawaiian floras. Field Mus. Bot. Ser. **22:** 405–441. 31 O 1941.

Skutch, A. F. The natural resources of Costa Rica. Chron. Bot. **6:** 399–402. N 1941.

Smith, L. B. Notas sobre Bromeliaceas de Paraguay. Rev. Arg. Agron. **8:** 192–195. *1 f.* S 1941.

Steyermark, J. A. Aquatic varieties of *Poa annua.* Rhodora **43:** 630–632. N 1941.

Thomson, J. W. Local flora notes. A new station for *Cetraria islandica.* Torreya **41:** 160. 30 O 1941.

Williams, L. The phytogeography of Peru. Chron. Bot. **6:** 406–410. N 1941.

Williams, L. O. A new *Acanthophippium* from Fiji. Am. Orchid Soc. Bull. **10:** 168, 169. *pl. 6.* 1 N 1941.

MORPHOLOGY

(including anatomy, and cytology in part)

(See also under Ecology: Daubenmire; under Genetics: Randolph)

Bannan, M. W. Variability in wood structure in roots of native Ontario conifers. Bull. Torrey Club **68**: 173–194. *f. 1–18*. 1 Mr 1941.

Bannan, M. W. Vascular rays and adventitious root formation in *Thuja occidentalis* L. Am. Jour. Bot. **28**: 457–463. *f. 1–27*. 8 Jl 1941

Blomquist, H. L. & Roberston, L. L. The development of the peristome of *Aulacomnium heterostichum*. Bull. Torrey Club **68**: 569–584. *f. 1–28*. 1 N 1941.

Farley, H. M. & Hutchinson, H. Seed development in *Medicago* (alfalfa) hybrids. I. The normal ovule. Canad. Jour. Res. **19**: 421–437. *f. 1–22*. N 1941.

Merry, J. Studies on the embryo of *Hordeum sativum*—I. The development of the embryo. Bull. Torrey Club **68**: 585–598. *f. 1–42*. 1 N 1941.

Ragonese, A. E. & Marco, P. R. Observaciones sobre la biologiá floral de la cebadilla criolla. Rev. Arg. Agron. **8**: 196–199. *f. 1, 2*. S 1941.

Saez, F. A. Alteraciones experimentales inducidas por la accion de la gravedad en las celulas somaticas de *Lathyrus odoratus* (Leguminosae). An. Soc. Cien. Arg. **132**: 139–150. *pl. 1–3 + f. 1–8*. 1941.

PLANT PHYSIOLOGY

(See also under morphology: Saez)

Dawson, R. F. The localization of the nicotine synthetic mechanism in the tobacco plant. Science **94**: 396, 397. 24 O 1941.

Franck, J. Some fundamental aspects of photosynthesis. Sigma XI Quarterly **29**: 82–105. *f. 1–16*. Jl 1941.

Fulton, H. J. Some factors that influence the immediate effects of pollen on boll characters in cotton. Jour. Agr. Res. **63**: 469–480. 15 O 1941.

Lewis, J. C. & Powers, W. L. Iodine in relation to plant nutrition. Jour. Agr. Res. **63**: 623–637. 1 D 1941.

Murneek, A. E. Sexual reproduction and the carotinoid pigments in plants. Am. Nat. **75**: 614–620. N–D 1941.

Reid, M. E. Relation of temperature to the ascorbic acid content of cowpea plants. Bull. Torrey Club **68**: 519–530. *f. 1–5*. 1 N 1941.

Zscheile, F. P. Plastid pigments. Bot. Rev. **7**: 587–648. N 1941.

MYCOLOGY AND PHYTOPATHOLOGY

Broadfoot, W. C. & Cormack, M. W. A low temperature basidiomycete causing early spring killing of grasses and legumes in Alberta. Phytopathology **31**: 1058, 1059. *f. 1*. N 1941

Cation, D. The line pattern virosis of the genus *Prunus*. Phytopathology **31**: 1004–1010. *f. 1–4*. N 1941.

Conners, I. L. *et al.* Willow blight in British Columbia. Phytopathology **31**: 1056–1058. *f. 1*. N 1941.

Davis, W. C. Damping-off of longleaf pine. Phytopathology **31**: 1011–1016. N 1941.

Frezzi, M. J. *Phytophthora Boehmeriae*, causante de la prodredumbre morena de los frutos citricos, en la Republica Argentina. Rev. Arg. Agron. **8**: 200–205. *f. 1–3*. S 1941.

Hansing, E. D. & Lefebvre, C. L. Smut sori from ovarial and staminal tissues of certain grasses. Phytopathology **31**: 1043–1046. *f. 1–2*. N 1941.

Jauch, C. La "Viruela de la púa" en los durazneros y almendros del nordeste bonaerense. Rev. Arg. Agron. **8**: 206–215. *pl. 9–10*. S 1941.

Johnson, T. & Newton, M. The effect of high temperature on the stem rust resistance of wheat varieties. Canad. Jour. Res. **19**: 438–445. *pl. 1*. N 1941.

Kernkamp, M. F. & Martin, W. J. The pathogenicity of paired haploid lines of *Ustilago zeae* versus the pathogenicity of numerous mixed haploids. Phytopathology **31**: 1051–1053. N 1941.

McKinney, H. H. Virus anatagonism, natural host resistance, and the acquired immunity concept with reference to plants. Phytopathology **31**: 1059–1061. N 1941.

McKinney, H. H. & Hills, C. H. Mosaic, chlorosis and necrosis in virus-infected perennial pepper caused directly by products of a deranged metabolism. Science **94**: 372, 373. 17 O 1941.

McLean, J. G. & Walker, J. C. A comparison of *Fusarium avenaceum*, *F. oxysporium*, and *F. solani* var. *eumartii* in relation to potato wilt in Wisconsin. Jour. Agr. Res. **63**: 495–525. *f. 1–8*. 1 N 1941.

Richardson, L. T. A *Phytophthora* tomato disease new to Ontario. Canad. Jour. Res. **19**: 446–483. *pl. 1, 2 + f. 1–9*. N 1941.

Riker, A. J. Attenuation of bacteria pathogenic on plants. Chron. Bot. **6**: 392, 393. N 1941.

Riker, A. J., Lyneis, M. M. & Locke, S. B. Comparative physiology of crown gall, attenuated crown gall, radiobacter and hairy root bacteria. Phytopathology **31**: 964–977. *f. 1–3*. N 1941.

Snyder, W. C. A fusarium wilt of Sweet William (*Dianthus barbatus*). Phytopathology **31**: 1054–1056. *f. 1*. N 1941.

Weimer, J. L. A leaf spot of peas (*Pisum* sp.) caused by *Cercospora lathyrina*. Phytopathology **31**: 1031–1034. *f. 1*. N 1941.

Weindling, R. Experimental consideration of the mold toxins of *Gliocladium* and *Trichoderma*. Phytopathology **31**: 991–1003. *f. 1*. N 1941.

Whipple, O. C. Injury to tomatoes by lightning. Phytopathology **31**: 1017–1022. *f. 1–3*. N 1941.

White, P. R. & Braun, A. C. Crown gall production by bacteria-free tumor tissues. Science **94**: 239, 241. 5 S 1941.

Woods, M. W. & DuBuy, H. G. Synthesis of tobacco mosaic virus protein in relation to leaf chromoprotein and cell metabolism. Phytopathology **31**: 978–990. *f. 1–3*. N 1941.

GENETICS
(including cytogenetics)
(See also under plant physiology: Fulton)

Beasley, J. O. Hybridization, cytology and polyploidy of *Gossypium*. Chron. Bot. **6**: 394, 395. N 1941.

Bryan, A. A. & Sass, J. E. Heritable characters in maize. Jour. Hered. **32**: 343–346. *f. 1–4*. O 1941.

Giles, N. Spontaneous chromosome aberrations in triploid *Tradescantia* hybrids. Genetics **26**: 632–649. *pl. 1 + f. 1*. N 1941.

Newcomer, E. H. A colchicine-induced tetraploid cabbage. Am. Nat. **75**: 620. N–D 1941.

Poole, C. F. *et al.* Inheritance of seed characters in watermelon. Jour. Agr. Res. **63**: 433–456. *f. 1–13*. 15 O 1941.

Randolph, L. F. Genetic characteristics of the B chromosomes in maize. Genetics **26**: 608–631. N 1941.

Smith, H. H. & Bacon, C. W. Increased size and nicotine production in selections from intraspecific hybrids of *Nicotiana rustica*. Jour. Agr. Res. **63**: 457–467. *f. 1, 2*. 15 O 1941.

Valle, C. G. del. Estudios geneticos sobre el maize. I. La produccion de Lineas Homogeneas. Mem. Soc. Cub. Hist. Nat. **15**: 307–317. *pl. 32–33*. 31 O 1941.

ECOLOGY AND PLANT GEOGRAPHY

(See also under Taxonomy and Floristics: Skutch)

Bond, R. M. & Wallace, A. M. Invasion of a protected area by exotic plants. Sci. Monthly **53**: 470–472. N 1941.

Cárdenas, M. Formaciones vegetales del Chaco. *In* Contrib. Flora Bolivia. Univ. Simon Bolivar 1–9. 1941.

Carpenter, J. R. The biotic community as an object of study. Chron. Bot. **6**: 386–388. N 1941.

Daubenmire, R. F. Some ecologic features of the subterranean organs of alpine plants. Ecology **22**: 370–378. *f. 1–24*. O 1941.

Dugand, A. Estudios geobotanicos colombianos. Descripcion de una sinecia tipica en la subxerofitia del litoral caribe. Rev. Acad. Colombiana **4**: 135–141. *pl. A, B*. Jl–Au 1941.

Graham, S. A. Climax forests of the upper peninsula of Michigan. Ecology **22**: 355–362. *f. 1–6*. O 1941.

Harper, R. M. Some effects of cold on plants in Alabama in 1940. Torreya **41**: 166–169. 30 O 1941.

Tolstead, W. L. Germination habits of certain sand-hill plants in Nebraska. Ecology **22**: 393–397. O 1941.

White, D. P. Prairie soil as a medium for tree growth. Ecology **22**: 398–407. *f. 1–7*. O 1941.

Wright, K. E. The great swamp. Torreya **41**: 145–150. 30 O 1941.

GENERAL BOTANY

(including biography)

Apolinar Maria, H. Vocabulario de terminos vulgares en Historia Natural Colombiana. Rev. Acad. Colombiana **4**: 142–157. Jl–Au 1941.

Arber, A. The relation of Nehemiah Grew and Marcello Malpighi. Chron. Bot. **6**: 391, 392. N 1941.

Good, H. G. Amos Eaton (1776–1842) scientist and teacher of science. Sci. Monthly **53**: 464–469. N 1941.

Haag, H. B. Rafinesque's interests—A century later: medicinal plants. Science **94**: 403–406. 31 O 1941.

Harter, L. L. William Williams Gilbert 1880–1940. Phytopathology **31**: 961–963. *port*. N 1941.

Harvey, R. B. Rodney Howard True. Chron. Bot. **6**: 424, 425. *port*. N 1941.

Haskell, D. C. The United States exploring expedition 1838–1842 and its publications 1844–74. III. Botany. Bull. N. Y. Pub. Lib. **45**: 833–847. *port*. O 1941.

Kempton, J. H. G. N. Collins. Chron. Bot. **6**: 426. N 1941.

McAtee, W. L. Names of American plants in books on Kalm's travels. Torreya **41**: 151–160. 30 O 1941.

Schaeppi, H. Robert Keller. Chron. Bot. **6**: 425, 426. N 1941.

Sears, P. B. A submerged migration route. Science **94**: 301. 26 S 1941.

Seifriz, W. Reproductive cycles in plants. Carib. Forester **3**: 11–24. O 1941.